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AËRONAUTICAL SOCIETY of GREAT BRITAIN

AN EDUCATIONAL COURSE OF
SIX TECHNICAL LECTURES

ON

The Theory, Design and Construction

OF

AEROPLANES

Will be delivered by the AËRONAUTICAL SOCIETY at the Northampton Polytechnic Institute, St. John Street, Clerkenwell, E.C., at 8 p.m. on each of the following evenings:—

1910.
Wed., Nov. 2. "The Study of Dynamic Flight"
By J. H. LEDEBOER, B.A.

" " 16. "The Mathematics of the Aeroplane"
By ALGERNON E. BERRIMAN.

" " 30. "Theory and Design of Propellers"
By T. W. K. CLARKE, B.A.

1911.
" Jan. 11. "Aeroplane Surfaces and Controls"
By H. F. LLOYD.

" " 18. "The Motive Power in Aeroplanes"
By CAPT. A. D. CARDEN, R.E.

" " 25. "Lines of Aeronautical Research"
By BERTRAM G. COOPER.

Discussion will be invited at the termination of each lecture.

Full particulars and tickets may be obtained on application to The Secretary, Aëronautical Society of Great Britain, 53, Victoria Street, S.W.

Telephone 3656 Victoria.

Notices of the Aëronautical Society of Great Britain

GENERAL NOTICES

September:—Lieutenant C. E. Colbeck, R.E.; J. Washington Wilson.
October:—W. P. Durtnall; Theo. Ridge.

At a meeting of the Council, on September 28, on the motion of the President, it was unanimously decided to despatch a message of condolence to the relatives of M. G. Chavez. The following reply has been received from his brother, M. M. Chavez:—

Paris: le 4 Oct. 1910.

Messieurs,

Je viens aux noms de mes frères et soeur vous remercier des marques de sympathie que vous nous avez temoignées dans notre malheur. C'est une consolation bien grande pour notre famille de voir que notre malheureux frère a emporté dans la tombe l'estime et l'admiration de tous les hommes, qui, comme vous, travaillent au triomphe de l'homme sur les forces de la nature et que vous avez admiré le dévoument de ce martyr de la science.

Recevez, Messieurs, avec mes remerciements l'assurance de ma grande considération.

(Signed)—MANUEL CHAVEZ

The attention of members is called to the series of technical lectures to be given by the Society at the Northampton Polytechnic Institute during November and January next. Particulars appear in the advertisement columns.

"The Aerial Ship," by Francesco Lana, has been published by the Society as No. 4 of the "Aeronautical Classics" series.

COMMITTEE NOTICES

Bird Construction Committee The report of this Committee is almost complete, and will be published in the next number of the "Aëronautical Journal." In view of its valuable nature, arrangements are also being made for its separate publication in pamphlet form.

Consideration of Inventions Committee This Committee have dealt with an immense number of inventions, but regret to report that a very small percentage were even practicable. The few upon which the Committee were able to report favourably did not, unfortunately, include any one of a greatly progressive nature.

Laboratory Committee The Laboratory Committee recently addressed a letter to the Press asking for samples of struts, bars and wires used on aeroplanes for experimental purposes. The Committee beg to render their thanks to the following firms who have kindly forwarded samples: The Mineral Ore Syndicate, Messrs. T. W. K. Clarke, Messrs. W. N. Brunton, Messrs. F. Handley Page, and the Bowden Wire Company, Ltd.

The work is now proceeding, and it is hoped to publish some results early next year.

Technical Terms Committee The Terms Committee have nearly completed their work. A preliminary report will be sent out to the Press almost immediately.

Wings Committee The Wings Committee have settled on their line of action, and experiments are proceeding. It is hoped that a full report will be available for publication in January next.

LIBRARY NOTICES

The Council of the Society desire to thank the following donors for their gifts to the Library:—Colonel F. C. Trollope, Mr. J. D. Tinline, Mr. Eric S. Bruce, M. Emile Wenz, and Mr. S. F. Cody.

The following have been added to the Library in addition to those mentioned under "New Books and Publications":—

Milla, K. Die Flugbewegung der Vogel 1895
Abridgments of Aeronautical Patent Specifications .. .. 1867—1904

OCTAVE CHANUTE

In response to a deep and wide-spread desire, the Council of the Aëronautical Society—as reported in the last number of the *Aëronautical Journal*—conferred upon Mr. Chanute the Gold Medal of the Society, in recognition of his distinguished services to the advancement of aeronautics. Arrangements were in train to entertain Mr. Chanute to a banquet and make the fitting public presentation of this, the highest award in the world of aeronautical science, to the distinguished visitor, when news was received that serious illness had overtaken him at Carlsbad where he had been staying with his daughters. His recovery, after removal to the American Hospital in Paris, has happily been complete ; but his visit to England was postponed and, upon October 1st, he sailed for home. In a series of communications to the Society, Mr. Chanute expressed his deep regret at being forced to abandon this visit to which he had looked forward with appreciation. It is earnestly hoped that, next summer, the Society will have an opportunity of welcoming this great pioneer to England.

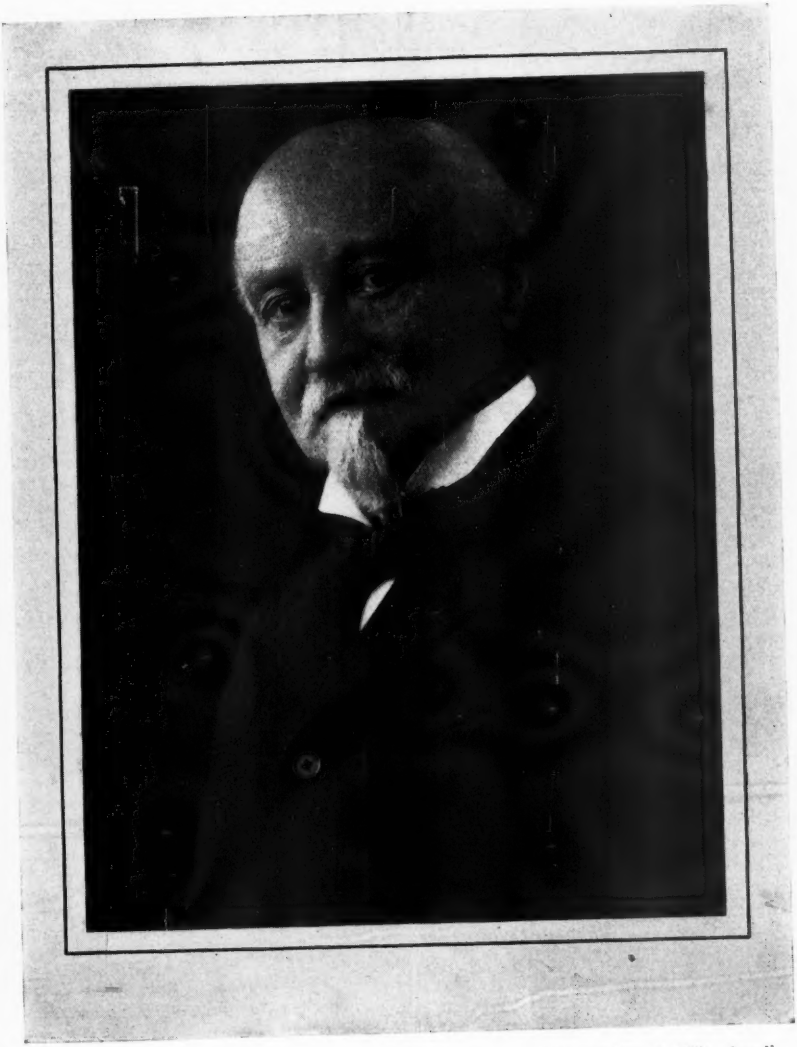
* * *

Octave Chanute was born in Paris of French parents on February 18th, 1832, and arrived in the United States at the age of six years. At the early age of seventeen he began to practise as a civil engineer and since that date—1849—he has been prominently associated with railroad engineering in the United States of America.

It was not until the late eighties that the possibilities of aeronautics seriously attracted him, and then, with the thoroughness that has characterised all his work, he proceeded to examine the entire history of dynamic flight from its earliest beginnings up to modern times. As a result of his researches a series of 27 articles was contributed to *The Railroad and Engineering Journal* (New York), starting in October, 1891. These articles were subsequently revised and gathered with certain additions into a single work published in 1894 under the title " Progress in Flying Machines." The most complete book on the subject to that date ever published, it has become a standard authority. Unfortunately, it is extremely rare.

In 1896, with Mr. A. B. Herring and Dr. Avery as assistants, Mr. Chanute undertook a most valuable series of gliding experiments. These experiments, in fact, were inspired by Lilienthal's example, and the first machine built was a Lilienthal glider which, however, was discarded even before Lilienthal's death, as being too dangerous. Several forms of gliders were tried, comprising in each case superposed surfaces varying in number from twelve to two. The type finally approved—a biplane with a tail—became the original of all biplanes in Europe as well as in America. When, in fact, just four years ago, dynamic flight was inaugurated publicly and practically, in France, the builders of the aeroplane which contributed most largely to this success—MM. Voisin — generously acknowledged their indebtedness to the work of Mr. Chanute. For Chanute's gliding experiments were carried out, unfailingly, with a strict scientific purpose, and the conclusions derived from these experiments proved of vast importance for the development of flight. They may be summarised as follows :—Stability of an aeroplane may, within limits, be preserved automatically, and should at all events be controlled by the adjustment of movable surfaces, rather than by shifting the centre of gravity ; the power required for flight, moreover, is relatively small.

His work directly inspired, not only the efforts of his French disciples, but the success of Orville and Wilbur Wright, whom he assisted with his advice and the benefit of his large experiences. In this respect his invaluable services are widely recognised ; not so well known is his constant and kindly assistance, active and pecuniary, to many of those who by their writings and experiments sought to advance the science of flight. His aeronautical work has, throughout, been unselfish in the true sense of the word ; steadfastly has he refused to seek personal benefit from the development of a science which he ever held to be the possession of entire humanity. Though time has scarcely yet given perspective in which to view his work, we may even now see within it the high and enduring qualities that make for permanent recognition.



[*By courtesy of "The Aero"*

OCTAVE CHANUTE

GENERAL MEETING

The third meeting of the forty-fifth session of the Aëronautical Society of Great Britain, was held at the Royal Society of Arts, John Street, Adelphi, on Tuesday, 25th October, 1910.

The President, E. P. Frost, Esq., J.P., D.L. Cambs., occupied the Chair.

The PRESIDENT in opening the Meeting said: Ladies and Gentlemen, I do not think it at all necessary for me to introduce Mr. Reid to you. He is already well known to you all in scientific attainments, and as President of the Society of Chemical Industry. It will, I think, be extremely interesting this evening to follow Mr. Reid in his study on this special subject of explosives, and it is hoped that the discussion afterwards will be as varied and as instructive as the discourse of Mr. Reid promises to be.

THE USE OF EXPLOSIVES IN AERIAL WARFARE, WITH SOME REMARKS ON METHODS OF DEFENCE

BY WALTER F. REID, F.I.C., F.C.S.

FROM the moment when human beings succeeded in raising themselves in the air their innate combative instincts led them to the consideration of how the new invention could be utilised against their enemies. The early literature of aeronautics teems with suggestions, more or less practical, for the use of balloons in warfare. The first attempts were anything but successful, although in some cases a certain moral effect was produced which may have had some influence on the progress of hostilities.

When, in 1794, the French "Compagnie d'Aérostiers" used a balloon against the Austrians, the Austrian soldiers are reported to have shown a "superstitious fear," which, no doubt, was of considerable utility to their enemies.

The French continued to use balloons with varying success until the beginning of the 19th century, when one of them, no less a person than Napoleon himself, appears to have been stricken with the "superstitious fear" that they had attributed to their enemies. At the Coronation festivities in 1806 Garnerin built a large balloon, profusely decorated, with a car shaped like the Imperial crown. It was liberated at Paris near Notre Dame, and the next morning passed over Rome and fell into Lake Bracciano. On the way, however, it touched the ground, and the crown was broken against the tomb of the Emperor Nero. When Napoleon heard of this ill-omened occurrence Garnerin was dismissed and came to England. The balloon is still preserved in the Vatican at Rome. That part of it which was constructed of oiled silk is quite rotten; but some cotton fabric which had been coated with a spirit varnish of a resinous nature is still sound.

After this action by the French military authorities it seems to have been assumed by other nations that balloons had not proved their utility in warfare, and many years elapsed before further use was made of them.

In 1812 a German mechanic named Leppen offered to construct for the Russian Government a balloon capable of carrying 50 men and a quantity of explosives to throw down into the ranks of the enemy. His experiments with small balloons, however, were a failure.

On June 22, 1849, at the siege of Venice, the Austrians used free balloons for the purpose of dropping bombs upon the town. The bombs were attached to the balloons in such a way that, after the burning of a certain length of safety fuse, the connection was severed and the bomb fell. The length of fuse was calculated according to the speed of the wind; but unfortunately, when the balloons rose, they entered an upper air-current travelling in a different direction from that below, and many of the bombs burst in the Austrian lines whence they had started. In 1861-2 General MacClellan made use of balloons, especially to give the correct range to his artillery.

In the war between Brazil and Paraguay in 1866 General Caxias used a balloon in the swamps of Neembucu; but it was promptly destroyed by fire.

There have been many cases of the destruction of balloons by fire where it has been quite certain that neither flame nor spark has been brought near them by human agency. It has been too readily assumed that they have been struck by lightning, although, in several cases, there have been no signs of thunderstorms in the neighbourhood. As a matter of fact, a balloon or an aeroplane with an oiled silk or rubber-coated fabric generates a considerable amount of electricity merely by passing through dry air. I have been able to produce sparks by simply blowing dry air against a piece of oiled silk. If the gas-bag should be electrically insulated from the car there is always danger, especially with dirigible balloons. With drifting globular balloons there is little friction between the air and the balloon, except in rapidly rising or falling. In dirigible balloons the escaping gases from the motor afford a means of dissipating any electricity that might accumulate in the car, provided there be electrical connection between motor, car and gas-bag. It must not, however, be forgotten that these issuing vapours may themselves generate electricity. It is probable that several deaths of aeronauts may be attributed to this cause, possibly that of Dr. Wölfert, June 12, 1897, and of Severo, May 12, 1902.

In the Franco-German War of 1870-1871 balloons played a prominent part, but more as a means of communication and observation than for the distribution of explosives. Especially during the siege of Paris they were of great use to the French as a connecting link with the outer world. In all, 66 balloons left the beleaguered town, of which 59 fulfilled their mission. Of the 409 carrier pigeons which left Paris as passengers in the balloons only 57 returned; but these carried no less than 100,000 messages.

During the siege of Paris Krupp constructed a special gun for attacking the balloons; this may now be seen in the Berlin arsenal. As soon as it was brought into use, however, the French escaped any possible danger from it by sending off their balloons in the night. The diameter of the French balloons was known to the Germans and, with the aid of a special telescope, the distance could be calculated. The head of a human being affords an approximate measure which may also be used for range-finding. In those days the Germans obtained their first balloons from England, Coxwell going out with them to instruct the aeronauts in their use.

Of late years foreign nations have devoted much attention to the subject of artillery for use against aerial enemies. The firm of Krupp, especially, has produced several guns for this purpose.

The 7·5 c.m. gun of this firm has seats for five men and storage for 62 shells. It is mounted on a car which weighs 4,300 kilos., the weight of the gun alone being 1,065 kilos. Each projectile weighs 5·5 kilos. (12 lbs. 2 oz.), and the horizontal range is given as nine kilometres. The vertical range is 6,300 metres.

A lighter gun of 6·5 c.m. gauge weighs with car 875 kilos., the gun weighing 352 kilos. Each projectile weighs 4 kilos. (8 lb. 13 oz.), and the extreme horizontal range is stated to be 8,650 metres (9,450 yards). The height of fire obtainable is 5,700 metres (18,700 feet). The initial velocity of the projectile is 620 metres (2,034 feet) per second. A coiled spring balances the weight of the gun when pointed above the horizontal.

For naval purposes Krupp has constructed a 10·5 c.m. gun weighing 3,000 kilos. with carriage. The projectile weighs 18 kilos. (40 lbs.). The muzzle velocity is 2,100 feet per second, and the shells discharge a train of smoke to facilitate aiming.

Ehrhardt in Düsseldorf has also built a special gun for use against aerial craft. Its bore is 5 c.m. and its barrel is 30 calibres long, while the length of the Krupp barrels is 35 calibres. The weight of the Ehrhardt gun alone is 400 kilos.; with car, ammunition and five men the weight is 3200 kilos.

French constructors also have been busy in the same direction, and the French Army has guns specially made for use against balloons or aeroplanes. At the present moment may be seen in Paris a Voisin biplane carrying a small quick-firing gun; but it does not yet appear to have been put to a practical test. Le Creusot have made trials with a new 305 m.m. gun, 39 feet long, firing a shell weighing 2 cwt. to a distance of 18 miles.

It is somewhat doubtful if a gun be necessary for use on an aeroplane, for if the latter rises to a height that is fairly safe from rifle fire a bullet would in falling acquire such a velocity that it would kill any human being it might strike. At a height of 3,200 feet the velocity would be about 460 feet per second. If bullets only are carried a very large number might be showered upon an enemy. As regards the dropping of explosives from balloons or aeroplanes the destructive effect has been much over-rated. The moral effect would, no doubt, be considerable at first; but constant exposure to any source of danger breeds such familiarity with it that its effect soon wears off. At present the carrying power of aeroplanes is so limited that the amount of explosive that could be dropped would not be capable of doing much more than local damage. The effects produced by the detonation of high explosives are usually exaggerated. As a general rule it may be stated that the more violent the local action of an explosive is the smaller will be the radius within which damage is done. For instance, a charge of dynamite, that will destroy a steel plate if exploded upon it, will not do so much damage in the vicinity as a charge of black powder that would not make any impression on a similar steel plate if exploded upon it.

Some interesting experiments have been made in the United States by Weaver on the relative strengths of various explosives which may be quoted as follows, always recollecting the local action above referred to :—

Explosive Gelatine	106
Nitroglycerine	100
Guncotton	83
Rackarock	62
Melinite, etc.	51
Fine Black Gunpowder	28

The difficulty of hitting a mark from a travelling dirigible is very great, especially if the latter should be at a height that would afford even relative safety from rifle bullets.

The difficulties and dangers of using dirigibles for aggressive purposes are so great that it is doubtful if they will be found of much use except for scouting purposes. While ordinary balloons have little difficulty in ascending and descending even in a fairly strong wind, the descent of a dirigible in safety necessitates, even in a moderate wind, the presence of a considerable number of trained men who would not often be available at the right spot during hostilities. A dirigible cannot be deflated so easily as a spherical balloon, and many types cannot be deflated in the open at all without serious risk to structural parts. Nearly all the Zeppelin dirigibles have been destroyed during landing; in fact, the life of a dirigible may be said to depend to a great extent upon the care taken in choosing the weather for its flights. Within the last two or three years a mighty enemy to the dirigible has arisen. The aeroplane has advanced so rapidly that it is even now capable of destroying the most efficient dirigible in a few minutes. The speed of the most recent types of aeroplanes is already double that of a dirigible, so that the aeroplane could easily rise above its bulky opponent. Once above the dirigible a handful of stones, dropped from a sufficient height, would suffice to penetrate the envelope; no explosives would be needed. The crew of the dirigible would be quite unable to protect themselves from an aeroplane immediately above them: aeroplanes can only be met by aeroplanes. In dull weather and at night, preferably at a low elevation, dirigibles might, in calm weather, approach the enemy without much danger to themselves; but the conditions which render them less visible also prevent their occupants from distinguishing clearly any objects which they might wish to injure or to photograph.

Chain shot, or their modern equivalent, might be extremely useful against a balloon. Single bullets have but little effect upon the envelope of balloons which may be hit many times without necessitating a descent through the escape of gas. As regards aeroplanes, they will undoubtedly be most difficult to hit, even by practised gunners.

The difficulty of hitting either balloons or aeroplanes would be materially enhanced by colouring them a neutral tint that would be less visible against the sky than the brilliant yellow now in vogue. That yellow is of very doubtful utility even for the pur-

pose which led to its adoption. It is a glaring advertisement for the unsuitability of india-rubber as a material for dressing impermeable fabrics rather than a preservative of that substance from the deterioration which it suffers from the action of light. Those who choose india-rubber for such purposes forget, or may not know, that Graham used that material as a permeable film in his experiments on the diffusion of gases, and found that hydrogen passed through it readily.

As to the uses to which both dirigibles and aeroplanes may be put in naval warfare many suggestions might be made; but little practical work has been done. For the protection of fleets from submarines there is little doubt that aeroplanes, even in their present stage of development, will be of great use. Those who have looked down into the sea from balloons know how distinctly objects may be seen at considerable depths in moderately clear water. An aeroplane could, in many cases, not only find a submarine, but could overtake it and destroy it with a comparatively small charge of explosive. As with the dirigible, so with the submerged submarine: it would be unable to repel such an attack.

It would be interesting to test the penetration of a small projectile fired vertically upon the deck of a destroyer from a height of, say, 3,000 feet.

In time, no doubt, aeroplanes will be constructed that can rise from and rest upon the water, and such craft would be invaluable as naval scouts, for their speed would greatly exceed that of any ship. Even now either aeroplanes or dirigibles might be used for clearing a way, by means of comparatively small charges, through a mined area, and in doing so they would not incur any serious risk as is the case with floating vessels engaged in similar work.

Both on land and sea, therefore, air craft have a great future, and even now cannot safely be neglected either as a means of offence or defence.

DISCUSSION

Colonel J. E. Capper: I should like to say a word or two of thanks to Mr. Reid for the lecture that he has so kindly given us. I was rather hoping that he would devote more of it to the specially technical question of explosives and their effects. He has told us that you can destroy a dirigible balloon by bursting in the neighbourhood a comparatively small quantity of explosive, and I imagine that his idea is that he would use his guns not so much to get direct hits as to put a bursting charge of high explosive somewhere in the neighbourhood of the balloon. I should rather like to know from him whether he is aware of any practical tests of this theory. I know it is a generally accepted theory. I know that certain experiments have been carried on, and I should like to know whether he has really any first-hand knowledge that he can give us of the actual results on balloons of exploding at definite distances from them definite amounts of high explosives or powder; that is, I think, a matter of the very greatest interest. I do not know whether he has that information, or, if he has it, whether he is at liberty to give it. And the same knowledge is required as to his statement that a comparatively small charge of explosive dropped into the sea near a submarine will destroy it. Of course we all know that if you drop a stick of dynamite into a pool of water you will bring a lot of fish, if there are any there, to the surface; the fish get stunned; a certain number of them in the immediate neighbourhood get killed. I won't detain you by asking too many questions, but I should like rather to join issue with Mr. Reid as to his statement that there are comparatively few days in this country on which dirigible balloons can work. Of course the dirigible balloon that we have actually had exper ence of in this country is not what you can call an up-to-date dirigible balloon, but I can assure Mr. Reid that as far as weather conditions go there are a great number of days on which dirigible balloons can work in this country. There are times, of course, when winds are too high, but the airships, the best of those of to-day, can go something like 35 miles an hour, and the days in which, at a comparatively small height above the ground, the wind in this country is as much as 30 miles an hour or even 25, are less than those in which it is under this, and in some seasons very considerably less. In some seasons of the year you might say that it is hopeless to expect dirigible balloons to work for more than a few days out of the month, but at other seasons you may expect to work them nearly every day. Then the question of clouds—

clouds are very useful to a dirigible balloon if it is trying to get about without being seen. There is a very generally accepted theory that you cannot navigate a dirigible balloon with any certainty if there are clouds above or if you are working above the clouds. That is only to a limited extent true. Air currents—except on very very calm days, in which case they are very divergent indeed and up and down currents are very frequent—when there is a fair steady wind at the same level, are in my experience in very much the same direction. They change their direction as you get into another level, but along the same general level they are in very much the same direction. If you have once got your proper direction, a compass bearing or a direction by the sun, by travelling over a piece of known ground you can identify it on your map. My experience is that you can go for a considerable distance above the clouds—not in them; you may be able to if you have got better compasses than we at present have—but using the sun as a guide, you come down again at intervals below the clouds and you will find that you are surprisingly close to the place where you anticipated you ought to be, if you have studied the subject at all closely. It is very interesting what Mr. Reid has to say about the yellow colour of the dirigible balloons, and coming from such an expert as he is, it is very useful information. We have always accepted the fact that the yellow colour was almost a necessity for the rubbered fabrics in order to prevent them from perishing from exposure to the sun's rays, and it is most interesting to know that we need no longer do so, and that they can be painted in ways which will make them less conspicuous. I have only one word more to say; I think that unconsciously, perhaps, Mr. Reid in treating of the airships and aeroplanes has rather treated the airship as it exists to-day as against the perfected aeroplane of the future. I quite agree with him that in the future the aeroplane will knock the dirigible out from war, but we are not in the future yet, and at the present moment I think that considering all the limitations of the existing aeroplane, of the nervous strain on the pilots which as we know unfortunately seems to make most of them discontinue the work after a comparatively short experience, the fact that there is no such nervous strain in dirigible balloons, and the distance that dirigible balloons can go, we cannot afford to neglect the dirigible balloon for the sake of perfecting the aeroplane.

Colonel Stone: I endorse Colonel Capper's thanks to Mr. Reid for the most interesting lecture that he had given us. He has not touched upon one aspect of the question. He has told us what may be expected from dirigibles and aeroplanes in war during the daytime: how far his anticipations will be realised I shall be sorry to hazard an opinion, as I have a very strong belief in experimental proof, but I am convinced of this, as a gunner, that it is very much harder to hit anything, whether you fire from the air or whether you fire from the land, than the untrained or non-professional man usually believes. The very highest training and constant practice is absolutely essential to perform even the smallest facts with regard to hitting the object that you aim at. I think before missiles discharged from guns or dropped either from airships or aeroplanes can be regarded seriously as likely to hit any definite small target at which they are aimed, we may have to wait a very long time for their crews to become sufficiently trained. But I do think that a dirigible may confidently count on being able to discharge large bombs at a comparatively short range at night with sufficient accuracy to hit such a large object as, we will say, a dry dock or a factory. In the same way an aeroplane armed, as a Voisin aeroplane in France has recently been armed, with a gun, may confidently hope to be able to hit a dirigible—of course it can come as close as it likes to it. But I do not think that in either case, so far as our present lights go, we need contemplate the action of dirigibles or aeroplanes as offensive weapons which will seriously disconcert an army in the field. The effect of high explosives, as Mr. Reid has, I think, very wisely pointed out, is extremely local. At the beginning of the South African War we thought that lyddite shell was going to work miracles: at the beginning of the Russo-Japanese War the Japanese thought that their high explosive shells were also going to work miracles: we learned by experience that neither of them really produced any very serious effect, beyond an extremely small radius, and that so far as the moral effect went, as Mr. Reid again pointed out, the moral effect was over as soon as you got used to it. But I quite agree with him, because I do not believe very much in the serious physical effect, that the moral effect of guns fired or bombs discharged from dirigibles or aeroplanes at

an army in the field will not produce any very serious disconcerting effect. Their use, so far as I can see, is a sufficiently extended one in the field of reconnaissance, and in that field I consider that they will be so valuable that the army which has them in fairly good working order, notwithstanding mishaps, notwithstanding many casualties, will reap an easy victory over the army which has them not. I now come to the special question which I mentioned at the outset of my remarks, the subject which Mr. Reid did not touch upon, that is, the use of dirigibles at night for discharging explosives. I believe from the experience gained by our own Balloon School that a dirigible can approach any locality at night very low down indeed on the horizon with much less risk of being discovered—I invite Colonel Capper's criticism if I am stating anything which is not absolutely accurate—than would be the case if it went at a considerable altitude. This is a very serious consideration, and if a dirigible has carefully reconnoitred any given locality during the day and mapped it out sufficiently to ensure the correct line being taken to its destination at night, not necessarily a very dark night, without being discovered in sufficient time to be destroyed at a distance, then it appears to me to be perfectly feasible for that dirigible to drop explosives on any given locality, with sufficient accuracy to cause very vital damage to such a large target as a dry-dock, and such a very vulnerable one, we will say, as a cordite factory. Now both of these things are of the very first importance to us as a Sea Power: the destruction of our supply of cordite on any large scale means that our Fleet would be absolutely powerless against an enemy: the destruction of four or five dry-docks would hamper the efficiency of our Navy to a degree which we cannot afford to contemplate without taking measures to prevent it. How this danger, if I am right in thinking that it is a serious one, is to be combated is as yet only a matter of discussion. Major Baden-Powell in a lecture at the United Service Institution, made suggestions as to how it might be combated by aerial torpedoes. Mr. Reid has stated his opinion that a dirigible can be rendered *hors de combat* by the explosion of a shell or an aerial torpedo in its vicinity. These, however, are rather vague terms, and I am very thankful that Colonel Capper brought forward the necessity for actual experiment before we accept any theories. In experiment, so far as I am aware, we have not succeeded either in this country or in any other country, in arriving at any reliable data. Krupp's guns are extremely interesting weapons of war to be used against dirigibles and aeroplanes, and firing shrapnel shell they would no doubt meet with considerable success if handled by expert gunners who had had ample opportunity of practising at similar targets, not targets going about ten miles an hour. But even using shrapnel shell under the most favourable auspices with the most expert gunners who had had far greater experience at firing at that kind of target than any gunners in the world have yet had, it would probably not suffice to render a dirigible *hors de combat*. They would have to discover the dirigible in sufficient time to be able to fire at it at a long enough range to prevent the whole thing from coming down on the top of their heads. If they did not discover this dirigible until it was practically over the fortified town—we will assume that the attack was on the dockyard at Portsmouth—it would be perhaps very inconvenient to ourselves if that dirigible with a heavy bomb of a thousand pounds of dynamite or something of that kind should come down in our midst. We might have brought it down, but in bringing it down we should expose ourselves to very unpleasant consequences, and as Mr. Reid pointed out quite correctly, the object needed is to bring it down at a very considerable distance off—an extremely difficult business at night. As regards the effect of dropping explosives, we have yet to learn what effect the explosion would have assuming that a dirigible drops a heavy bomb, about a thousand pounds, on the locality which it is aimed at. We do not know from what height it would be necessary for that dirigible to drop its bomb in order to assure its own safety from the subsequent concussion. That is one direction in which I think experiment is required. Another direction in which experiment has gone a very long way in Germany, and I believe unsuccessfully, is to what extent we can destroy dirigibles completely, that is, not firing shrapnel shell at their crew in the hope of killing a few men or possibly damaging the machinery, but with the hope of bringing the whole thing down, exploding the envelope. These experiments, such as they have been, have naturally been kept dark, but I do not believe so far as my information goes, that it has been found possible as yet to explode a dirigible

by firing any kind of shell of any sort at it. The envelope is of non-inflammable material, the gas when the envelope is penetrated, if the hole is sufficiently large, comes out in considerable force. That gas is not explosive unless it is mixed with air, and I believe I am correct in saying that experiments with a view to exploding the contents of the gas bag by this means have failed. This leaves us, as I have said before, in the very serious position that, so far as we are aware, the dirigible at the present moment has us at a great disadvantage : when I say us, I speak not particularly of England, but of any country against which a dirigible may be used. The possibility of dropping bombs into the sea and thereby rendering submarines *hors de combat* by bursting in their shell, I think requires experiment in order to verify it before we can accept it. I shall be very glad if Mr. Reid can give us any further information with regard to what he would propose our methods should be to prevent dirigibles from carrying out the form of attack which I have suggested at night.

Major BADEN-POWELL : I have only one point and that is, what would be the effect of exploding high explosives on the ground under the point where an aeroplane was soaring ? One might have a simple system of defence by having explosives placed at convenient intervals about, and when an aeroplane comes over that district to explode some of these charges. It seems to me that a current of air of a very turbulent nature would be caused to rise and eddy about, and it is possible when the aeroplane entered that it might be upset by the action of air, but I am not prepared myself to test what the effect on such an aeroplane would be, and I don't suppose we shall get many volunteers to try how the aeroplane would behave when a discharged explosive had gone off just beneath it.

Mr. CODY : I should like to say a word or two in answer to Major Baden-Powell's suggestion that these explosives might be placed about on the ground. Of course if aeroplanes or dirigibles were made of glass I naturally would admit that an explosion near them would break them, but flexible as they both are I don't think an explosion would hurt them, if the fragments of the shell did not hit them. And as regards an aeroplane it might have a big hole torn in one side of it, but if it has any balancing device it could be easily kept straight. As to the suggestion that the wind from the explosion would damage the aeroplane, if the Government will allow anyone to explode heavy explosives in the neighbourhood where I carry out experiments I am quite prepared to fly over them, that is if they do not use more than a hundred or two hundred lbs. of gun cotton or any other explosive, and I can assure you if it does push the aeroplane out of its position, I will gain my balance before it gets to anything hard enough to break it. So I do not think there is any danger to the aeroplane. But I am quite a believer in the limitation of the aeroplane in war. I don't think it is going to do great things yet myself. And as regards seeing the submarine in the water to hit it or anything like that, I have had some experience in trying to find submarines in the water, and I couldn't find them. Twelve hundred feet high I couldn't see them. One day I could see the chains that held two buoys in the Solent and another day I couldn't see them at all, it all depended on how muddy the water was, and as a rule submarines hover about harbours where the water is muddy or stirred up a good deal by traffic, so I should think the submarine would be fairly safe against that part of the aeroplane, and the submarine certainly could attack the aeroplane by shooting up from a gun by its periscope when it is out of the water.

Colonel F. C. TROLLOPE : During the last Boer War there was only one balloon that was really absolutely hit by gun fire, and that was in charge of Mr. Phillips. There was a shrapnel shell burst in front of it, it made 68 holes through it and it took twenty minutes to come down. I know about that because I happened to be the Superintendent of the Balloon factory during the War. It was sent home to me to be patched or done something with. I mended it. The distance the gun was away from Mr. Phillips I believe was 600 yards—the balloon went too near the guns and not high enough. That was the only balloon that was hit during the whole of the War that I know of. It might interest you to know that that was a captive balloon : how much more difficult will it be to shoot a rocketting dirigible ?

Mr. WALTER F. REID in replying said: Colonel Capper has given us some extremely interesting information, and he has asked as one would have expected, very pertinent and important questions with regard to actual facts. I have not myself used any bursting charge near a balloon, I have not had the opportunity of doing so, but I know that such experiments have been made in Germany, and that the results were not altogether in accordance with the view which I expressed. They were made with a captive balloon, and so far as I can tell, the balloon was not quite as tight as a dirigible would be. The effect of course will depend upon the tension of the fabric; the pressure of the gas that exists in the balloon that is exposed to the pressure of the explosion. If the gas bag should be slack, then probably very little effect would be produced, if on the other hand you have got a tense gas bag, like you might have in a dirigible balloon, the effect would probably be greater. But, so far as I am aware, the actual experiments I have heard of have not been conclusive and do not altogether agree with the statement which I made on general grounds. Colonel Capper has exactly pointed out the effect which is produced on fish when an explosive is exploded in their neighbourhood. He said that the fish are stunned and some recover and some do not. If he had examined those fish that have not recovered as I have many times, he would have found that the swimming bladder was in every case burst. That is quite a different thing from pressure in the air, but we also know that pressure in the air is propagated a very considerable distance. I have noticed in many explosions that I have had to inquire into, where destruction of property has ensued, the pressure on for instance a pane of glass is very considerable indeed from a small charge. A pane of glass is a thing that we know stands an ordinary amount of even extraordinary velocity, but if you explode say a couple of ounces of dynamite ten or twelve yards off a pane of glass, it will go.

A MEMBER: Outwards or inwards?

Mr. REID: It goes outwards. If you were to open one of these doors here and explode something in this room you might have the adjoining glass go inwards. It is quite true that very often a back current of air is stronger than the current outward from the explosion. There is a very curious thing too, that if the body is an elongated one and the explosion comes from some considerable distance, even if it has a very great power indeed, that body is very little injured. At the great explosion at Stowmarket where many tons of gun-cotton went off, the whole factory was absolutely razed to the ground with one exception, the factory chimney—that is standing uninjured now. The wave of the explosion seems to have got round it and although it may have rocked a little and it was a little cracked, it is still standing, yet the whole factory went down. In another case I know of, where a factory was destroyed, an explosives factory, the same thing happened, the chimney stood after all the building. I suppose, therefore, if you could get a dirigible balloon something like the fiery dragons of old going through the air, an explosion would not hurt them: we should go back to the fairy tales of our youth. Perhaps I did not explain myself quite clearly when I referred to the few days that we had the air clear. I was referring to the dirigible balloons taking photographs and making observations. It is quite true that there are very many days in the year when you can work as regards the wind, there is no question whatever about that, but my argument was more to the effect that, unless you have a large number of men ready in the landing of a balloon and that you can anchor it carefully and accurately, there is very great risk of any balloon ultimately coming to grief. The danger is great if you come down in a place, even in a moderate wind, if you cannot immediately anchor your balloon or get it into a place of safety. I think Colonel Capper will agree with me when I say that it is in the coming down that the difficulty arises more than in the navigating.

Even with regiments of men dotted all over Germany where the Zeppelin airships were likely to come, they have all come to grief practically, but I don't suppose that Colonel Capper would build a Zeppelin. Colonel Stone has given us most interesting particulars, and I feel very much indebted to him for having increased my knowledge on many points. He also referred to what Colonel Capper said, "that it is not fair in any way at all to compare the airship of to-day with the aeroplane of to-morrow." That is quite right, it is not fair. It is not fair at this present moment to say that any aeroplane

taken at random would be capable of destroying even one of our present day dirigibles, but I think I did guard myself somewhat by saying that next year probably, if the progress goes on as it has gone on during the past year, aeroplanes will be quite different things from what they are to-day. Therefore, I think we are justified in looking a little towards the future. Although I know that the dirigibles will not remain stationary and that we are very active in developing them, yet I do think that the development of the aeroplane will be very much more rapid than the further development of the dirigible. Colonel Stone has said one thing which is full of interest to everybody, that is that you cannot hit a moving thing. You want to practise, practise, and practise before you can even get anywhere near hitting it. Those of you who are sportsmen, know if you are firing at a partridge that is going across rapidly, you will be absolutely certain to miss it if you aim at it. That is where experience comes in. You must estimate the speed of the bird, you must estimate the distance, and in former days you had to allow a little for the spread of your shots. It would be a most difficult thing now to hit a swiftly moving aeroplane. When it is a long way off it appears to be moving slowly, it is of course, moving rapidly ; you can aim at it, but long before the shot or shell reaches the spot you have aimed at, the aeroplane is somewhere else. It is a most elusive thing to try and aim at a rapidly moving target, especially if it is moving as I hope aeroplanes will, at a speed of 80 to 100 miles an hour. I also entirely agree with Colonel Stone with regard to dirigibles at night. They cannot be seen if they are low down, and the only hope to find them out is through two ways. The one is by wireless telegraphy : a network of wireless telegraphy around such places as dry docks, or forts ; (I won't say cordite factories, because they are invulnerable) but wireless telegraphy, or telephones even, could advise people of their coming, because there is one thing that these all have in common at present at any rate, and that is their noise. None of them are silent, some of them make less noise than others, but I believe that a series of microphones placed on elevated spots, or perhaps in captive balloons, would give you timely warning of the approach of anything coming through the air, and vibrating as they do vibrate, and as a matter of fact the noise is really a nuisance. I happen to live within sound of Brooklands, and on a Saturday afternoon in the summer, I always think my bees are swarming, for now and then there is a buzz just like a swarm of bees, and it is the aeroplanes practising. My wife came to me one day and said : " They have been coming over the garden, what shall I do ? " I said : " Put up your umbrella and keep off the castor oil, that is all I can tell you to do." The aeroplanes have come to stop ; how we shall defend ourselves from them I really do not know from the domestic point of view. I do not quite agree with Col. Stone ; I think that even if you dropped a very large charge of dynamite into a cordite factory, you could not do it any serious damage. If you were to drop an explosive charge into one of the magazines where large quantities of cordite are stored, I could mention four or five magazines in this country, where the effect would be very disastrous, and the diminution of the supply of explosives to our Navy or our Army would be serious. But in a cordite factory, all the buildings are surrounded by mounds, and they are isolated from each other, and every precaution is taken to prevent the propagation of an explosion from one to the other. I have seen many explosions or the results of many of them in explosives factories, and I have put up a good many explosives factories, but I should not anticipate any serious damage at all from an explosive charge dropped into a cordite factory. Even a magazine of fourteen or fifteen tons of dynamite might explode without injuring the adjoining magazines. The Government ensure the right distances, they specify the proper distances, and it is almost an accident if the second building should go off. They are all protected by mounds up to the eaves of the buildings, and therefore the explosion that takes place in one building is driven upwards and does not affect the rest. It has been proposed to protect all buildings by means of a wire netting over them from falling burning beams or bits of wood or falling stones or débris of any kind in case one building should go off. That is the only danger that is left. A piece of an adjoining building might possibly be blown into the air and fall into the pit in which the next building is situated, and it is proposed to protect them by stretching over the top of the building an expanded metal. Experiments made where a very heavy weight was dropped from a high tower on to a net of expanded metal placed in such a way as it would be over a

magazine of explosives, and it did not go through at all. The elasticity was so great that the shock was absorbed and there was no penetration. Therefore, I think if aeroplanes were to become general and there was a chance of any damage from falling dirigibles, it would be a very simple matter for the Government to cover all the magazines with a network placed on iron or steel posts around the building, and stretched across to prevent any heavy article from falling on to the magazine, and the rest of the magazine might be made of re-inforced concrete. I think we might protect magazines, but with regard to factories I should not be very much afraid.

There have been a few experiments made with regard to the vulnerability of dirigibles as regards the effect of bullets or shrapnel. There were two companies in Germany who did their best to destroy the gas bag of a captive balloon and bring it down. That was in June last. The results were absolutely ineffective. A good many holes were made in the fabric, but they automatically sealed themselves up. The gas escape was so infinitesimal compared to the volume of gas still remaining in the gas bag that there was not the slightest danger of the balloon being brought to earth. That concurs entirely with my own view of the matter that it is very difficult indeed for bullets or shrapnel to bring a dirigible down. Of course, an aeroplane might be different. If you hit the vital part or if you hit the aeronaut, a bullet might do damage in that way, but with regard to the penetration of bullets, if you make your fabric double and the inner fabric slack, then it will seal itself. I have tried experiments in that way and the inner fabric very often covers the hole made in the outer one and seals it almost perfectly, especially if the inner one is either damp or slightly slackened. Sir Frederick Abel made a number of experiments with regard to the action of explosives in water. He showed that the explosion was propagated most efficiently by means of water, and so efficient was it that he invented a water shell, and I believe he patented it—at any rate I myself have made a number of experiments. I found that the propagation of an explosion through water was so complete and so efficient that I used it for breaking up vessels of cast-iron on very many occasions. In the explosives factories we have great iron vessels in which sulphuric acid and nitric acid are concentrated. The cast-iron is about two inches thick. If you take one of these vessels—it would be about six to eight feet in diameter and about two or three feet deep, or perhaps even more—and fill it with water and explode a charge of dynamite of about four or five ounces in it, it will all go to pieces. If on the other hand, you take the same quantity of dynamite and explode it loosely in the vessel it will only make a small hole in the bottom. It shows that the water propagates the explosion, as we know, of course from hydraulic laws, that the water is practically incompressible. It is quite different, of course, with gas, and perhaps we have only to rely for the effectiveness of a charge in the air near a balloon on the very great weakness of the fabric which is being attacked, and if that fabric should be tense and full of gas then it might burst. But with regard to the fabric itself, there again a question arises, if the fabric should be an elastic one there would not be the chance of bursting it at all—you couldn't burst it. With regard to Major Baden-Powell's remarks as to explosions on the ground. There is no reason why an explosion should not be propagated a little higher, and rockets used. Now rockets that are used for pyrotechnic purposes go a certain height, I might say an uncertain height, but they go to a limited height, they are not intended to go any higher—if they went out of sight there would be no advantage in it—but it would be quite possible and I would undertake, to construct a rocket that would go up a mile if we wanted it. It is a question of size and a question of adjusting the charge for the work to be done, and you may get a rocket that would go up in an instant and strike a balloon. There, of course, the chance comes in of missing the balloon, but you could make it go up, and could make it explode at a certain height, and that height might even be regulated at the moment of sending it off. With regard to the visibility of submarines, I quite agree with Mr. Cody. I think he mentioned it all depends upon the water. I think it also depends upon the sky. I myself have gone over perfectly clear water and not been able to see things if the sky has not been clear. If the sky and the water are nearly the same colour, it is very difficult. Of course, in muddy water you cannot see anything.

Mr. Cody: I may say that the skies I worked in were all overhung with fog and clouds.

Mr. REID: Have you ever seen clearly with a cloudy sky?

Mr. CODY: I have never tried on a clear day.

Mr. REID: Mr. Cody has to some extent corroborated what I said about our climate. He has not been able to find a clear day, but I hope he will succeed in the future and find some clear days. Colonel Trollope gives us most interesting information about actual fact: there is nothing like practical work and there was a case where the balloon took twenty minutes to come down, and was perforated in many places, and it agrees, I think, with all our opinions and experience, that it is very difficult indeed, by means of simple projectiles, to bring a balloon down. I think those are all the points.

The PRESIDENT: Before thanking Mr. Reid I find that Mr. Cody has some interesting slides that he would be pleased to show on the screen, and I understand that Mr. Cody will be good enough to present the slides to the Society.

The photographs were shown on the sheet and Mr. Cody explained them.

The Meeting then terminated.

THE LAWS OF AIR SCREWS

I.—THE SCREW WITHOUT AXIAL MOTION

By W. R. TURNBULL, M.E.

In the design of aeroplanes, I have been constantly hampered by lack of reliable formulæ that would give the thrust and horse-power required for a given diameter, pitch, speed, etc., of screws. The theoretical formulæ are too complex and uncertain for concrete computations, so I have undertaken an experimental study of air screws and have endeavoured to deduce formulæ, from the experimental data, which shall be reliable and at the same time cover the complexities that must enter with screws of widely differing elements such as blade area, form, pitch, etc.

M. S. Drzewiecki, in his excellent theoretical study of Air Screws*, says "the question of screws in general is very complex and poorly enough understood from a theoretical standpoint," and we might add it is almost equally complex and little understood from the practical and experimental standpoint.

In this first paper I present results of tests on air screws without motion in the axial direction ("au point fixe")†, but in a second paper, which I expect to publish in a few months, I will present the results for the same propellers with axial motion.

Up to the present time the only well-known laws of air-propellers deduced from direct statorotary experiments have been as follows:—(1) The square of the lifting power varies as the cube of the number of revolutions per minute; (2) the expenditure of work per unit time varies as the cube of the number of revolutions per minute; (3) the lifting power for a given expenditure of work varies inversely as the number of revolutions per minute.‡

These laws, while true in a general sense, give no hint of the important part played by the diameter, pitch, etc., and give no concrete formulæ for calculating the horse-power expended and the thrust obtained. With the distinct aim of investigating particularly the influence of diameter, width of blade, pitch, etc., on the power and thrust, this work was undertaken.

* "Des Hélices Aériennes" Paris, 1909.

† For brevity let us speak of *statorotary* motion, thrust, etc., when there is no axial motion.

‡ W. G. Walker and P. Y. Alexander, *Engineering*, 16/2/1900.—*Illustrierte Aeronautische Mitteilungen*, 1900; No. 3.

The experimental data obtained establish the important laws that, for propellers of similar form and statorotary motion, *the thrust varies as the fourth power of the diameter, and the power consumed varies as the fifth power of the diameter*; the formulæ obtained being :—

$$\text{Thrust} = UR^2D^4 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$
$$\text{Power} = QR^3D^5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

in which U and Q are quantities depending on pitch, type, blade, width, units employed, etc., taken necessarily from curves representing the types, R the revolutions per minute, and D the diameter. These laws will be more fully discussed after describing the experiments.

The prime mover employed was a specially-built $\frac{3}{4}$ HP. series motor (capable of 100 per cent. overload for a short time) with an especially long shaft on the end of which the propellers were mounted, to avoid the influence on the air of the motor and its support. This motor was driven by current from a storage battery, insuring constant potential, and its speed could be varied by a German-silver resistance frame. The motor was most carefully calibrated for efficiencies at all speeds and currents within its range, and was mounted on a small platform, delicately suspended by long wire vertical supports, to obtain with accuracy the various thrusts.

The thrusts were directly weighed by weights placed in the scale-pan *S*, Fig. 1. *w*, w^1, being the suspension wires, *M* the electric motor on the suspended platform, *P* and *p* being a frictionless pulley, and *r* a stop for the index rod *i*.

The speeds were accurately obtained by means of the speed counter *C*, which was connected to the motor shaft by a light flexible spring-shaft. The speed counter has an electric contact by which a bell is rung every 100 revolutions, the times being taken by a stop-watch for several hundred revolutions. This speed counter has many advantages over the hand-applied counter, as there can be no slipping, no variable pressure, and the brake tests of the motor were made with this device attached.

The propellers used were carefully made of white pine glued in strips after the manner of a lady's folding fan, and afterwards formed by hand to the true screw shape. The

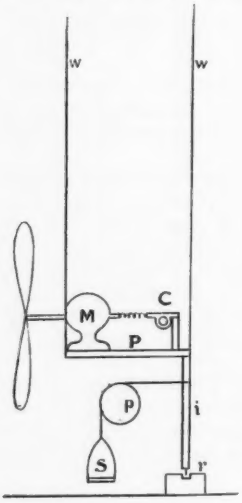


Fig. 1

Fig. 2

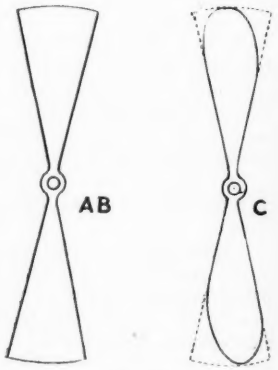


Fig. 3

blade cross-section of set A being flat on the driving side (see *A*, Fig. 2) and that of set B being concave on the driving side (see *B*, Fig. 2). Set A and set B had the sector shape with circular tips (see *A B*, Fig. 3), while set C (made by paring down set B)

had the leading edge and part of the following edge pared away in the manner usual to several modern aeroplane propellers (see *C*, Fig. 3). Set B was made from set A by concaving the driving side, and in this way we get direct experimental evidence on the much discussed question as to which is the better form of blade.

The construction data of the various screws employed are given in the following table, the sixth column, curvatures of blades, applying to sets B and C only; the blades of set A being flat on the driving side :—

TABLE I.

Set of Exps.	No. of screw	D Diameter in feet	P Pitch in feet	P/D Pitch-co-efficient	Curvature = depth Camber ÷ width.	Average Value of "U" 0·000000	Average Value of "Q" 0·0000000000	Value of "Useful effect" = L × P × R
A	VIII.	2·5	1·015	·4065	None	0732	01103	26,950
	VI.	2·504	1·412	·565		0959	01438	37,700
	IX.	2·5	2·025	·810		1274	02686	38,400
	I.	1·493	1·483	·995				
	II.	1·996	1·984	·994		average	average	average
	III.	2·504	2·492	·995		1541	03598	43,900
	IV.	3·0	2·923	·975				
	V.	3·5	3·388	·968				
	X.	2·5	3·008	1·203		1805	0516	42,150
	VII.	2·495	3·49	1·399		1840	0623	41,200
	XI.	2·498	3·99	1·598		2043	0821	39,800
	XII.	2·497	4·97	1·994		2073	1036	39,850
B	IIIb.	2·5	2·49	·995	0·017	1819	0438	41,600
	IIIbb.	2·5	2·49	·995	0·034	1895	0448	42,400
	VIIb.	2·5	3·49	1·399	0·021	2010	0698	28,800
C	IIIc.	2·5	2·49	·995	0·034	1735	0441	39,300
	VIIc.	2·5	3·49	1·399	0·021	1931	0667	29,200

Considering first set A, it will be noted that the arrangement is in the order of the pitch-co-efficient, which was varied from 0·406 to 1·994; propellers I.—V. were varied in the diameter, the pitch-co-efficient being about unity in each case; in propellers VI.—XII. the diameter was practically constant at 2·5 ft., while the pitch was varied through a wide range.

For propellers I.—XII. inclusive, the width of blade at tips was 20 per cent. of the diameter. It is unnecessary to give the table of propellers with varying width of blades, as the results are sufficiently set out in the curves (Plates I. and II.); the widths were varied with propellers of 2·5 ft. diameter.

The fourth column gives the pitch in feet, the figures given being the average of several measurements on each blade of the finished screws, worked out with the well-known pitch-formula, viz. :—$P = 2\chi\pi \tan \alpha$, in which χ = distance from centre of hub, α = angle of slope at χ, and P = pitch (in the same unit as χ).

The seventh and eighth columns give the values of "U" and "Q" in formulæ (1) and (2) respectively when British units (foot, pound, etc.) are employed. The ninth column gives the "useful effect," which will be discussed further on in this paper.

Sets B and C are, perhaps, too meagre to draw general conclusions therefrom, but the column of "useful effect" indicates the advantage of concaving the driving side of the blades. The advantage of Form C (Fig. 3) is not clearly indicated over that of the simple sector shape (*A B*, Fig. 3); however the data are insufficient in this case to form any definite conclusions.

In turning to a consideration of the curves, Plates I. and II., and of the formulæ to be used therewith, it must be clearly borne in mind that they apply strictly to propellers having flat blades of the sector and true screw shape, although in cases of departure from this the formulæ may still be used and give approximate results.

The laws that thrust varies as D^4 and power varies as D^5 are, of course, only true when the screws are kept *in the same proportion to the diameter;* for instance, a screw of 20 per cent. width of blades will measure 4·8 ins. across the tips for a 2-ft. screw, and 9·6 ins. across the tips for a 4-ft. screw. This element of width of blades is an important one in the values of "U" and "Q," as can be seen by examining Plates I. and II., in which the experimental results are graphically given.

While formulæ (1) and (2) express *perfectly general laws*, where any type of screw form is concerned, and independent of units employed, the curves here given apply only to British units (foot, lbs., etc.), although curves for other units would be of similar form and easy to construct.

The formulæ for use with curves Plates I. and II. are :—

$$T = UR^2D^4 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (a)$$

$$B.H.P. = QR^3D^5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (b)$$

In these formulæ T is the statorotary thrust in pounds, U the value corresponding to any pitch-co-efficient and width of blades (in per cent. of diameter) taken from Plate I., R the revolutions per minute, D the diameter in feet, B.H.P. the brake horse-power (British), and Q the value corresponding to any pitch-co-efficient and width of blades (in per cent. of diameter) taken from Plate II.

The curves for 20 per cent. width of blade are most complete and accurate, being drawn through eight points as the result of experiments with twelve propellers (the point at $P \div D = 0{\cdot}985$ being an average for five propellers I.—V.).

The other curves, 5 per cent., 10 per cent., 15 per cent., 25 per cent. and 30 per cent., were drawn by obtaining experimentally one point in each case (marked x) at $P \div D = 0{\cdot}942$ and producing the curves in their similarity to the 20 per cent. curves.

While the curves for U and Q have considerable divergence, according to the width of blades, the divergence in the case of the "useful effect" curves (Plate III.) is only slight, showing that the width of blade, within reasonable limits, is not an important factor, at least in so far as statorotary results are concerned.

To illustrate the use of these curves we will take an example : Suppose we wish to know the statorotary thrust and required B.H.P. of a 6-ft. sector propeller having a pitch of 6 ft. and a blade width (at tips) of $\frac{20}{100}$ D, or 14·4 ins., at a speed of 1000 r.p.m.

From the 20 per cent. curves on Plates I. and II. we have $U = 0{\cdot}000000154$ and $Q = 0{\cdot}00000000000365$, $P \div D$ being $6 \div 6 = 1$; $D^4 = 1296$; $D^5 = 7776$. Substituting these values in formulæ (*a*) and (*b*) we get :—Thrust = 199·5 lbs.

B.H.P. = 28·4.

In a similar way the thrust and required B.H.P. for any propellers of varying width of blades, pitch, diameter, etc., can easily be found, and while the curves (Plates I. and II.) are strictly applicable only to sector propellers having flat blades, the formulæ and curves should give a close approximation for ordinary propellers of true screw form.

Where the propeller is of an unusual type, or varies much from the true screw, it would be a simple matter to test a single example of the type in question and measure its thrust and B.H.P. ; then these results could be substituted in formulæ (*a*) and (*b*) and values of U and Q could thus be determined for the type in question. These values could then be plotted in Plates I. and II. by the similarity of curves, and a set of curves so obtained would offer a close approximation for all diameters, pitches, etc., of this type.

We now turn to a consideration of the "useful effect," which is defined, by the writer, as the lbs. per B.H.P. (L) multiplied by the pitch speed ($P \times R$).

$$\text{Or "useful effect"} = L \times P \times R \quad \ldots\ldots\ldots\ldots \quad (c)$$

It has been a common custom, when dealing with air-screws, to consider the lbs. per B.H.P. (L in formula (*c*)) as a measure of the useful effect, but this quantity should certainly be multiplied by the "pitch-speed," which is the pitch in feet multiplied by the revolutions per minute. For it is quite possible, by making the diameter great, the pitch fine, and the number of revolutions per minute very small, to obtain as a value for L almost any value we wish; although such a screw would be most inefficient as a propelling mechanism where a considerable speed was required.

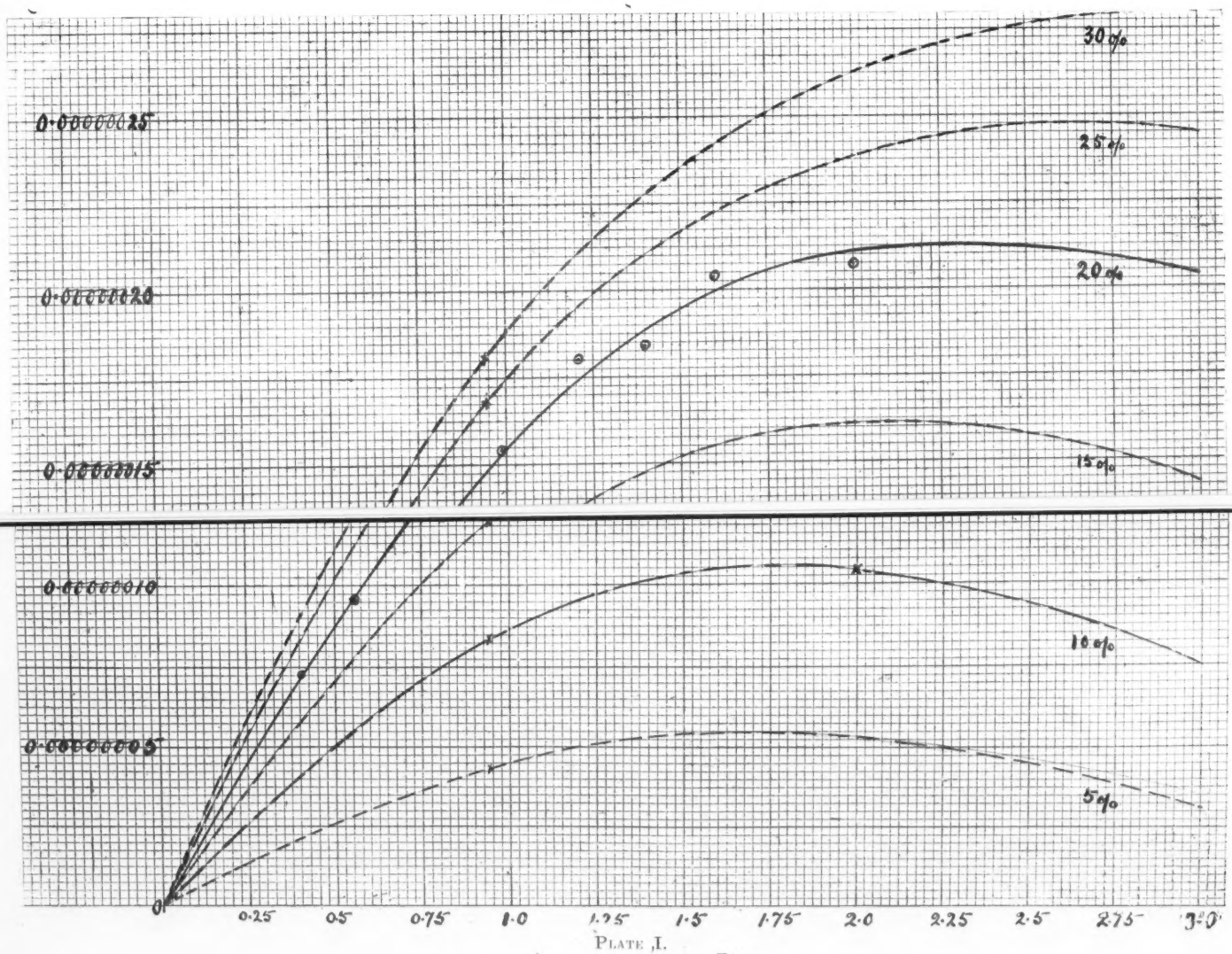


PLATE I.

$\left(\text{Pitch-coefficient} = \frac{P}{D}\right)$

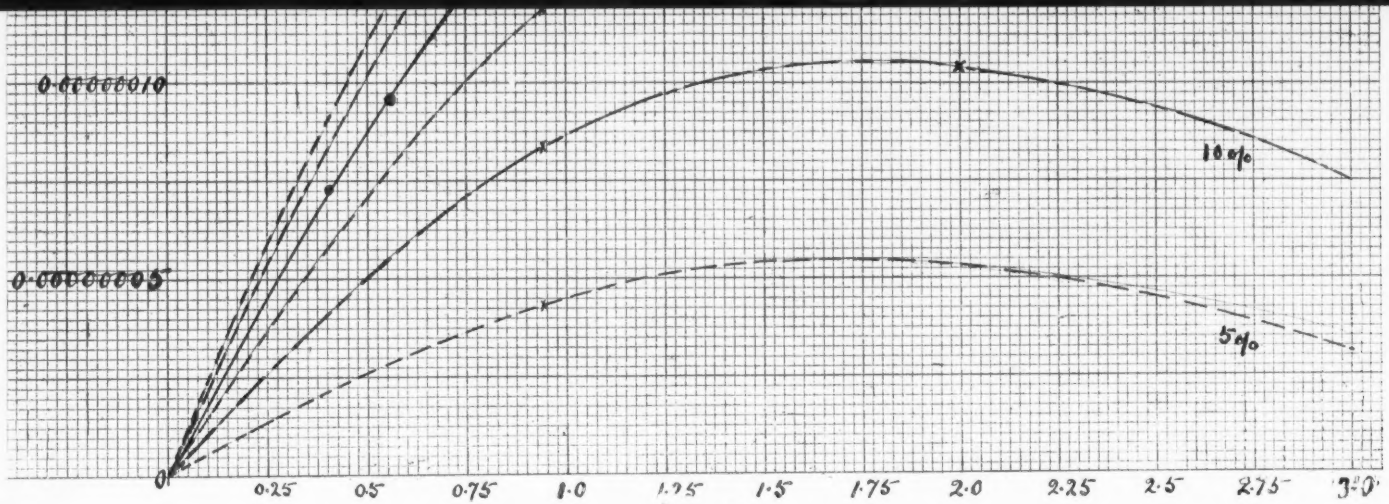
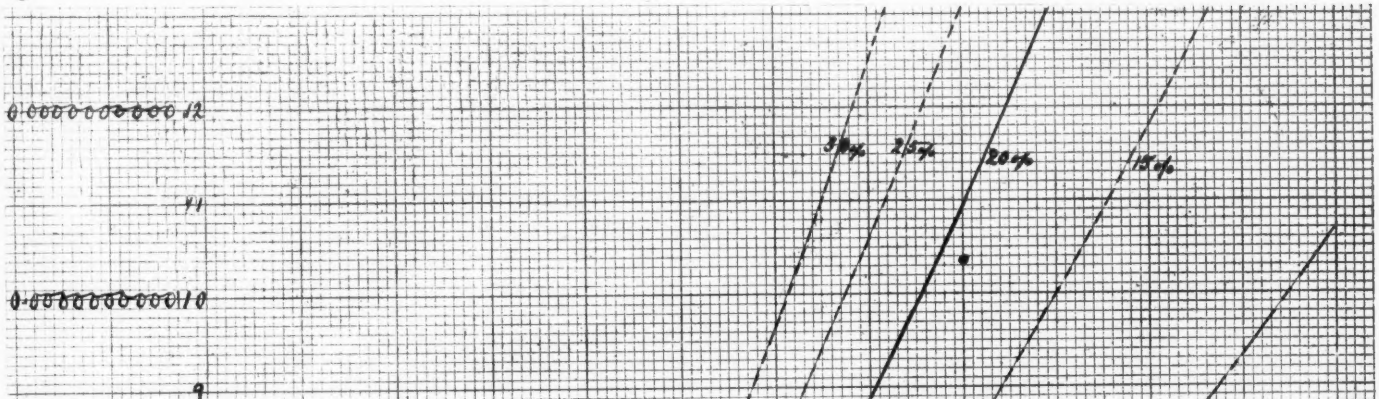


PLATE I.

(Pitch-coefficient $= \frac{P}{D}$)



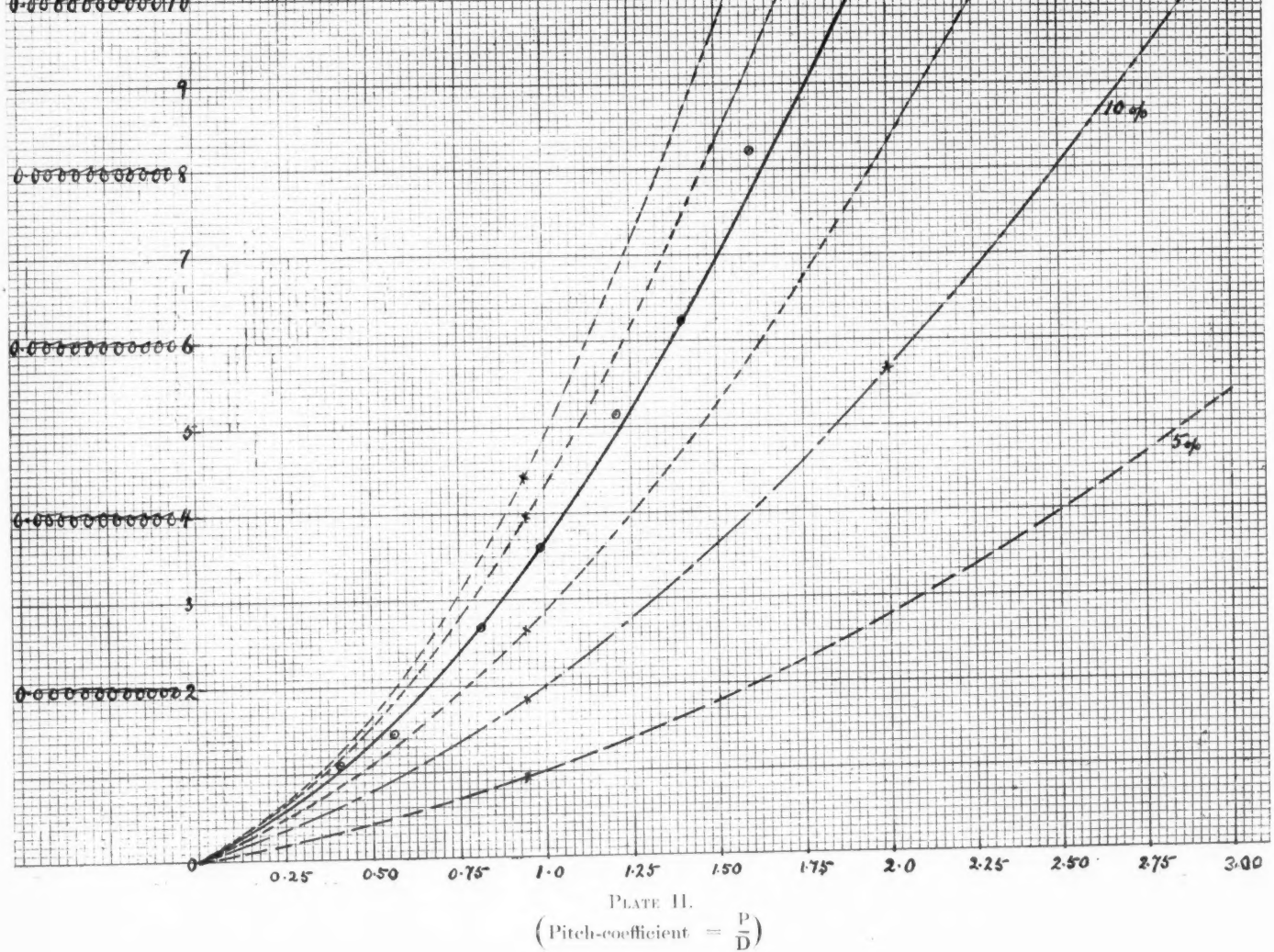
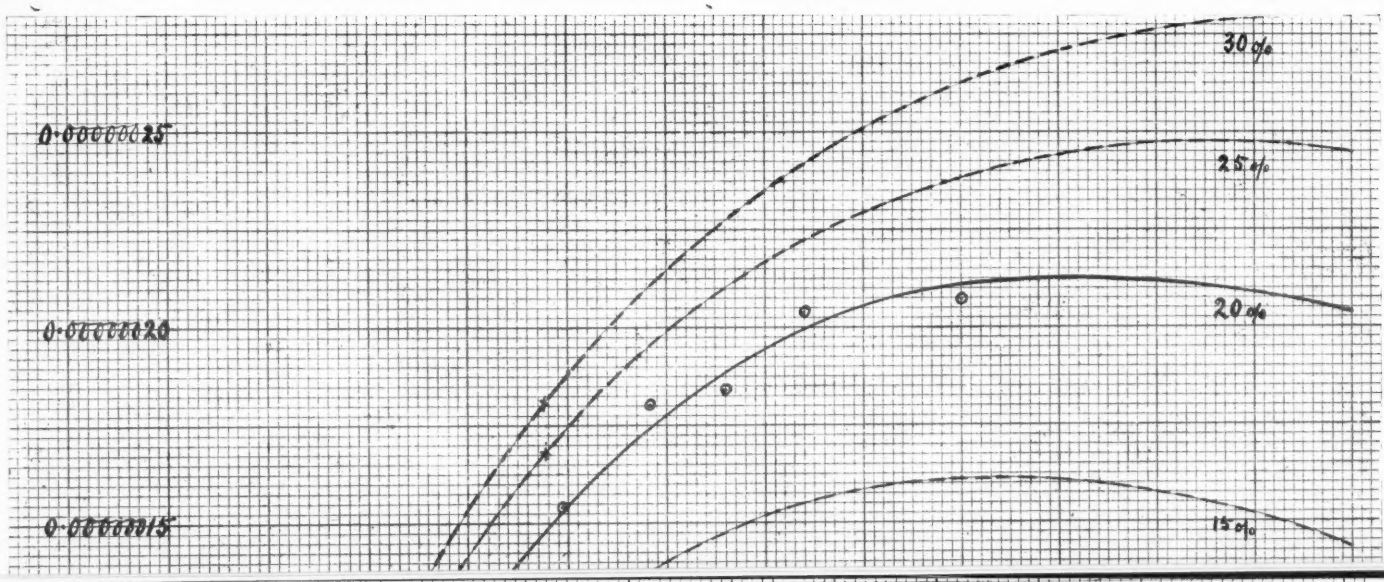
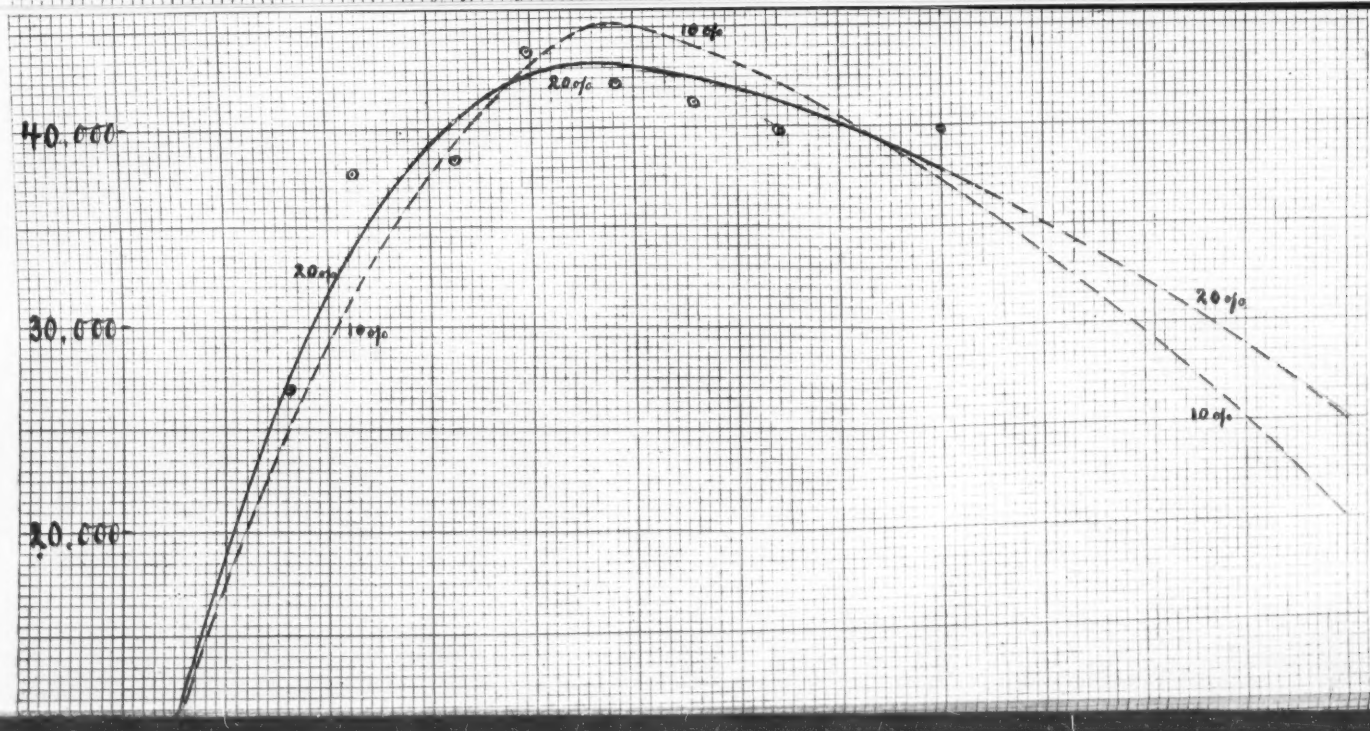


PLATE II.

(Pitch-coefficient $= \frac{P}{D}$)


0·000000025
0·000000020
0·000000015
30 o/o
25 o/o
20 o/o
15 o/o
Value of "U"


40,000
30,000
20,000
10 o/o
20 o/o
20 o/o
10 o/o
20 o/o
10 o/o
"Useful effect" = P N I N h

"Useful effect" = P × L × R

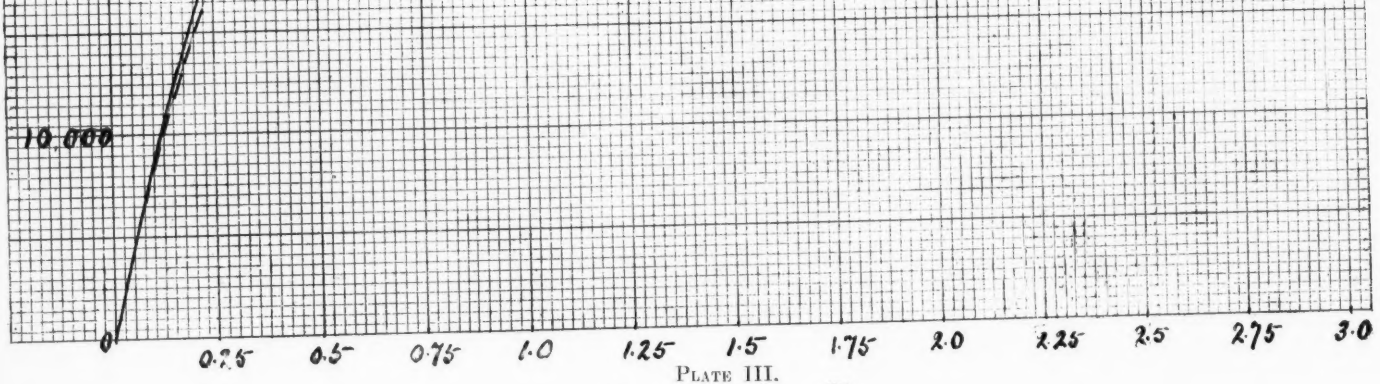


PLATE III.

(Pitch-coefficient = $\frac{P}{D}$)

For instance, a sector propeller of 20 ft. diameter, 2 ft. pitch and 20 per cent. width of blades, would give 570 lbs. per B.H.P. at 10 revolutions per minute, but the pitch speed would only be 20 and the "useful effect" only 11,400, as against a possible maximum of about 43,000 with propellers whose pitch co-efficient is about 1·2.

By dividing formula (*a*) by formula (*b*) we get a value for L, viz. :—

$$L = \frac{T}{B.H.P.} = \frac{U}{Q} \times \frac{I}{RD}$$

and when we substitute this value of L in (*c*) we get

$$\text{Useful effect} = \frac{U}{Q} \times \frac{P \times R}{R \times D} = \frac{U}{Q} \times \frac{P}{D} \quad \ldots\ldots\ldots\ldots (d)$$

The "useful effect" is therefore *independent of the speed and diameter*, but depends greatly on the ratio $\frac{P}{D}$ viz., the pitch co-efficient; as can be seen in referring to Plate III., where the maximum is plainly indicated at about $\frac{P}{D} = 1{\cdot}2$.

The "useful effect" is only slightly dependent on the width of blade (although a narrow blade is indicated for maximum effect), and this perhaps explains why "any old thing" in the form of a propeller has frequently given *fair* results.

Plate III. also explains why the fine pitch French propellers are wasteful of power and why the Wright propellers (with their pitch-co-efficient of 1·2) have taken the lead in point of efficiency.

To illustrate the independence of "useful effect" on diameter and speed, I append Table II., in which the diameters and speeds are varied while the pitch-co-efficient (=0·5) remains constant and the "useful effect," in each case, works out at 30,700.

TABLE II.

D Diameter feet.	P Pitch feet.	R Revs. per minute.	L Thrust per B.H.P. (computed) formula.	P×R =Pitch speed.	L×P×R or useful effect.
2	1	100	307·0	100	30,700
2	1	500	61·4	500	30,700
2	1	1000	30·7	1000	30,700
2	1	1500	20·45	1500	30,700
4	2	1000	15·36	2000	30,700
6	3	1000	10·24	3000	30,700

The fourth column, L, is computed from (*a*) and (*b*), and it will be noted that the lbs. per B.H.P. are inversely proportional to the pitch-speed, making "useful effect" *constant* for any given pitch-co-efficient and type of propeller.

While these results are both interesting and valuable as far as they go, they apply only to statorotary tests, and it remains to be seen to what extent these laws will be modified by giving the screws axial motion.

The writer is engaged in this work at the present time, and hopes in the course of a few months to publish the results of the test.

THE HARMONIOUS WORKING OF FLYING-MACHINE, PROPELLER AND MOTOR

BY PROFESSOR HERBERT CHATLEY, B.Sc.

In the discussion on the author's paper to the Society of Engineers (Dec. 1908) the author pointed out that the "propeller settled down to the speed determined by the characteristics of the *motor*, and that the torque, and consequently the thrust, would vary in a manner depending on the motor as well as on the actual form of the propeller" (p. 278, *Trans. Soc. Eng.*, 1908).

Elsewhere he has pointed out that "it is desirable to run the propeller at only a little above the normal speed of the aeroplane"*, and in the April (1909) number of the *Aeronautical Journal* it was shown how a rough synchronism of the propeller and motor might be obtained. The method employed there is open to the objection that propeller thrust is not amenable to the process of integration† over the surface. [See Froude "on the Elementary Relations between Slip, Pitch and Propulsive Efficiency," *Trans. Inst. Mar. Arch.*, 1875, and Lanchester "Aërodynamics" § 205, p. 300, and the author "Problem of Flight," chap. ii.), but since it was only sought to determine general constants (which would be empirically computed in a practical case) this may be overlooked.

It is the object of the present paper to consider not only the relation between the propeller and the motor but also between both of these and the flying machine.

The aeroplane will be designed to run at a certain speed depending on its resistance, weight and stability. This speed we will call V. It is obviously essential to the proper working of the machine that both the motor and propeller should, when there is this speed of advance, be working at maximum efficiency, and it will follow from this condition that :—

(1) The propeller thrust must equal the flying-machine resistance at the speed V.
(2) The corresponding torque of the propeller must equal the torque of the motor (or of the gearing driven by the motor).
(3) The propeller must be working with small slip.
(4) The revolutions of the motor must be such that it is working with high efficiency.

It will necessarily be impossible to secure all these conditions perfectly and it will be a matter of adjustment to secure an approximation to the required synchronism. It must, however, be realized that no flying-machine can be said to work efficiently unless these conditions are more or less realized. There are many machines which are defective in this respect and it is probable that the Wright and Voisin machines owe a large part of their success to a proper appreciation of this.

Let us consider for a moment what happens when the machine commences to run. The motor is started (let us suppose it is direct coupled) and since at first there is no load it races until the torque caused by the resistance of the propeller equals that which it can produce at the corresponding speed. At the same time there is a thrust which propels the machine. The machine advances with a resistance increasing after soaring commences until finally the resistance equals the thrust at the corresponding speed. The thrust has been decreasing slightly during the advance owing to the fact that the angle of attack of the propeller decreases and also on account of the skin friction. The decrease is not so great as might be expected, since the resistance at first decreases because of the smaller angle of attack and consequently the speed increases. As soon as the thrust is balanced by the flying-machine resistance, and at the same time the torque of motor and propeller is balanced, the acceleration of both machine and propeller will cease and the propeller will run steadily at a certain number of revolutions per minute (neglecting slight frictional losses). We have then the state of balance suggested in conditions (1) and (2) above, but *not necessarily at the required speed V*. Thus, let us suppose when the speed V has been

* Journal of the Royal Society of Arts, 1908, p. 139.

† Note that the symbol 'dp" is printed "ap" by error in the 2nd col. of p. 52 and 1st col. of p. 53.

reached by the aeroplane, the thrust has not diminished to the amount of the aeroplane resistance, then it will continue to decrease, the revolutions increasing and the machine accelerating until a higher speed than V is attained.

Or again, we may suppose that the thrust reaches the same value as the resistance of the aëroplane before the speed V is attained. In this case unless the power can be increased it will never be possible to reach the speed V.

Furthermore we must notice that supposing conditions (1) or (2) are realised, unless (3) and (4) are also true there will be a large amount of energy wasted at the engine or propeller or both.

In order to get some idea as to the conditions and also to avoid the more tedious and (in this case) inaccurate method of integration, we will assume that the propeller can be represented by an area A, which can be regarded as acting at its radius of gyration and from the axis of rotation. The speed of rotation is in revs. per second. If the pitch angle (say at the radius of gyration) be θ, then when v is the speed of advance the angle of incidence is approximately $\left(\theta - \frac{V}{2\pi n r}\right)$ and the normal pressure is :—

$$N = \kappa A (v^2 + 4\pi^2 n^2 r^2) \left(\theta - \frac{V}{2\pi n r}\right) \quad (1)$$

The axial component of this is the thrust

$$T = \kappa A (v^2 + 4\pi^2 n^2 r^2) \left(\theta - \frac{V}{2\pi n r}\right) \text{Cos } \theta \quad (2)$$

while the transverse component is, when multiplied by r, the torque

$$M = \kappa A r (v^2 + 4\pi^2 n^2 r^2) \left(\theta - \frac{V}{2\pi n r}\right) \text{Sin } \theta \quad (3)$$

For greater accuracy we should take into account the skin friction which for the whole tangential force is

$$F = \xi \kappa A (v^2 + 4\pi^2 n^2 r^2)$$

having components F Sin θ axially, and F Cos θ transversely so that (2) becomes

$$T = \kappa A (v^2 + 4\pi^2 n^2 r^2) \left[\left(\theta - \frac{V}{2\pi n r}\right) \text{Cos } \theta \; \xi \text{ Sin } \theta\right] \quad (2a)$$

and

$$M = \kappa A r (v^2 + 4\pi^2 n^2 r^2) \left[\left(\theta - \frac{V}{2\pi n r}\right) \text{Sin } \theta + \xi \text{ Cos } \theta\right] \quad (3a)$$

According to Lanchester ξ is about 0.02, and since θ will be (generally) about 15°, the value of ξ Sin θ will be about ·005. We cannot afford to neglect this since when $\theta - \frac{V}{2\pi n r}$ becomes small as it will do when v increases, ξ Sin θ may bear an appreciable ratio to $\theta - \frac{V}{2\pi n r}$ Cos θ.

If now we denote the aeroplane resistance R as a function of v, we have

$$R = f(v) \tag{4}$$

and for the designed velocity V, $R = f(V)$. Let us further write the horse-power of the motor as $H = F(n)$, where n is the revolutions, then the torque of the motor is found by

$$\frac{M.\,2\pi n}{55} = F(n)$$

$$M = \frac{275}{\pi n} \cdot F(n) \tag{5}$$

so that the two conditions (1) and (2) are represented by the equations

$$\kappa A(V + 4\pi^2 n^2 r^2)\left[\left(\theta - \frac{V}{2\pi n r}\right)\operatorname{Cos}\theta - \xi \operatorname{Sin}\theta\right] = f(V) \tag{6}$$

and

$$\kappa A r (V^2 + 4\pi^2 n^2 r^2)\left[\left(\theta - \frac{V}{2\pi n r}\right)\operatorname{Sin}\theta + \xi \operatorname{Cos}\theta\right] = \frac{275}{\pi n} \cdot F(n) \tag{7}$$

These equations are *not necessarily* simultaneous for the given value of V, but if the machine is to run at the speed V, then r, A, θ or F (n) must be modified so that they *are* simultaneous (or nearly so).

As to the two other conditions (3) and (4) it is necessary that $\theta - \frac{V}{2\pi n r}$ should be approximately 6°, and that the value of n in the equation (7) should be a little less than that which gives the maximum B.H.P., say n_1, or $F(n_1) = H_1$ almost the maximum B.H.P.

These conditions will fix the values of $F(n_1)$, and θ, so that there are only two unknowns A and r, and the equations being made simultaneous we can solve for them.

Multiply (6) by r tan θ, and subtract (7).

$$-\xi \operatorname{Sin}\theta . r . \tan\theta - \xi r . \operatorname{Cos}\theta = f(V) . r . \tan\theta - \frac{275}{\pi n_1} \cdot H_1 \tag{8}$$

$$r = \frac{275\,H_1}{\pi n_1 [\xi \operatorname{Sin}\theta . \tan\theta + \xi \operatorname{Cos}\theta + f(V) . \tan\theta]}$$

where $\theta = 6° + \frac{V}{2\pi n_1 r} = 0.1 \text{ radians} + \frac{V}{2\pi n_1 r}$

so that if we approximate $\theta = \tan\theta = \operatorname{Sin}\theta$, and say $\operatorname{Cos}\theta = 1$

$$r = \frac{275\,H_1}{\pi n_1\left[\xi\left(0.1 + \frac{V}{2\pi n_1 r}\right)^2 + \xi + f(V)\left(0.1 + \frac{V}{2\pi n_1 r}\right)\right]} \tag{9}$$

$$= \pi n \left[\frac{0.01\xi . 4\pi^2 n_1^2 r^2 + 4\pi n_1 r . V . \xi + \xi . V^2 + 4\pi^2 n_1^2 r^2 \xi + 4 f(V) . \pi^2 n_1^2 r^2 + 2\pi n_1 r f(V) . V}{4\pi^2 n_1^2 r^2}\right.$$

which can be reduced to a cubic equation.

Having found r, A can be calculated from (6) or (7). It will not be usual to work out the dimensions exactly in this way, because there are several other difficulties in connection with the shape of the blades, interference with the body, etc., which must be considered. The main point to be noticed is that (1) the resistance of the machine at the speed required and the thrust of the propeller must equate; (2) the torque of the propeller must equate that of the motor or gearing at the same speed of the aeroplane; and (3) the propeller and motor must both be working near their highest efficiencies when the two previous conditions apply.

Let us now consider the problem in its more practical aspect, for while the above method can without much difficulty be applied to an actual case, it will probably happen that the aviator has estimated the power required, from the resistance and velocity of his machine, has ordered his motor, and is only really concerned with the form of the propeller.

He should then proceed somewhat in the following manner. Test the motor on a frame and obtain the characteristic, i.e., the relation between the brake horse-power and the revolutions. This will give the value of H in terms of n or what we have called F (n) in the above analysis. The propeller may be now approximately designed to give the thrust required at the given speed of advance, with unity pitch ratio, the pitch angle at the tip will be $\tan^{-1}\left(\frac{1}{\pi}\right)$ = about 17° and assuming that there is no great change from the tip to the radius of gyration we shall have $\frac{V}{2\pi n r}$ is about $\tan^{-1}$ (11°), say ·2 radians. V is given and n can be taken to be the speed of maximum efficiency of the motor (shown as the abscissa under the maximum ordinate of the motor characteristic), so that

$$r = \frac{V}{2\pi n \times \cdot 2} = \frac{V}{1 \cdot 25 n} \text{ approximately.}$$

This is the value of the radius of gyration. The actual radius of the propeller will be a little more.

Next we must find the area of the propeller. The thrust will be roughly

$$T = \cdot 006 A (V^2 + 4\pi^2 n^2 r^2). \times \cdot 1 \times 0 \cdot 95$$

$$\text{say } \cdot 0006 A (V^2 + 4\pi^2 n^2 r^2)$$

$$\text{so that } A = \frac{T^*}{\cdot 0006 (V^2 + 4\pi^2 n^2 r^2)}$$

[V is here in feet per second and T in lbs.].

Roughly shape the propeller blades to have the required area, and then test the propeller. It should be coupled to the motor in the same manner as it will subsequently be arranged on the aeroplane, and then tried on a motor car or railway truck. It will be necessary to observe the thrust (this can be done with a sliding shaft and stop collar separated by a calibrated spring) in lbs., the revolutions, and the velocity of the car. The blades must be now fined down so that the thrust in lbs. is that required at the same time as the velocity of the car is that required of the aeroplane and the revolutions of the motor are those giving the maximum efficiency. This will be probably a tedious job but certain points may be noticed. The propeller will probably be running too slowly at the required car velocity and not giving the required thrust. Since the slip angle will not now be altered, if the resistance is decreased the thrust will increase so that rounding the section of the blade will increase both the revolutions and the thrust. If this is still insufficient the blades should be hollowed on the near faces. This will in-

* T is the resistance in lbs. of the aeroplane at the required speed.

crease the thrust without much lessening the resistance, so that the propeller will give more thrust with about the same revolutions. If the revolutions are too great then the pitch angle should be slightly increased, although this must not be done to any great extent since it impairs the efficiency of the propeller. If the thrust and revolutions are both much too low, then the area on the radius needs to be increased.

It will probably be necessary to make several propellers before a good balance is obtained, but there can be no doubt as to the final advantage of securing the conditions. If the attacking angle is too small the propeller will race and waste energy in overcoming skin friction and the motor will probably be running at low efficiency. If the attacking angle is too large then the ratio of thrust to torque is too low and energy is wasted in overcoming resistance, and probably again the motor will be running at low efficiency.

It must be remembered that propellers do not accommodate themselves to the angle of attack in quite the same way as aeroplanes, so that the existence of a proper angle of attack (about 6°) is a matter of design.

As a final reminder of the essential principle, it may be pointed out that the efficiency of the aeroplane is a product of three factors :

$$\eta = E_a \cdot E_p \cdot E_m$$

where E is the efficiency of the aeroplane itself (a matter which is not discussed in this paper), E_p is the efficiency of the propeller, and E_m is the efficiency of the motor. Each of these efficiencies is a function of the velocity of the machine; E_a for obvious reasons, E_p because upon that velocity depends the slip, and E_m because the slip affects the revolutions of the propeller and this affects the output of the motor. A low value for any one of these efficiencies reduces the total efficiency so that a machine of maximum aerodynamic efficiency may be utterly spoiled by an improperly designed propeller or motor, or *by an improper combination of the two.*

STREAM-LINE FLOW OVER INCLINED PLANES AND BODIES

By A. P. Thurston, B.Sc.

In July, 1909, the author read a short paper describing an apparatus for investigating the flow of air about propellers, aeroplanes, etc., which was published in the Aeronautical Journal for October, 1909. This apparatus has thrown a considerable amount of light upon various forms of flow. The photographs accompanying this article, which were taken in the Aeronautical Laboratory of the East London College (University of London), are merely illustrative of the results which can be obtained*.

Mr. Patrick Alexander recently showed the author an experiment demonstrating the effect which an inclined plane has upon the air above and below it. An inclined plane was mounted at the end of the arm of a whirling table and two horizontal planes on the end of flexible wires were placed above and below the inclined plane so as to be at equal distances above and below its upper and lower edges respectively. It was found at all speeds that the *upper plane* was always *more violently* agitated than the lower one. This would appear to indicate that the suction effect on the top of a plane has a more far-reaching effect on the air, which probably is in a more unstable state than the air underneath. The photographs Figs. 2 to 6 inclusive show conclusively that the back of a plane plays a most important part in affecting the air. The accompanying photographs were taken in a current of air which could be driven up to a speed of 1,800 feet per minute.

Fig. 1 shows the stream-line flowing on either side of an aerocurve set at an angle of 12°. The stream-line follows both sides of the plane.

* The author most gratefully records his indebtedness to the skill and kindness of Mr. A. G. Field, who took these photograph under his direction.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

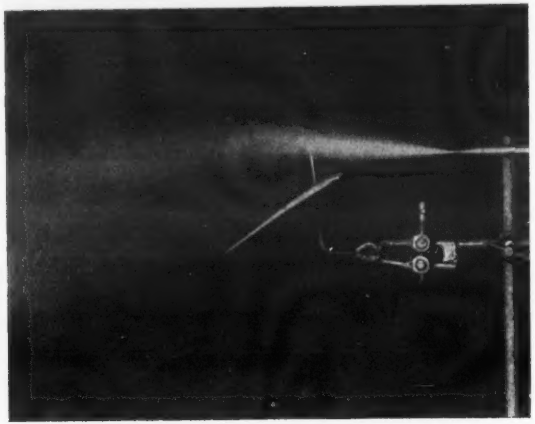


FIG. 5

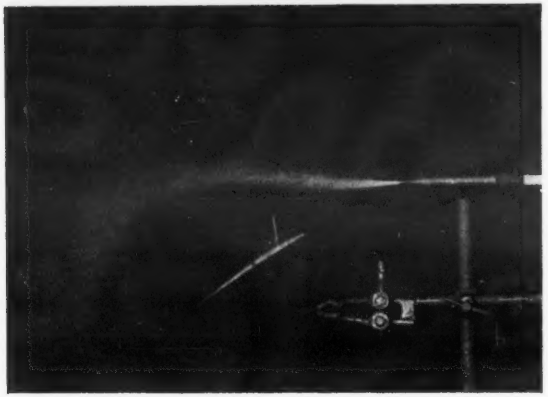


FIG. 6

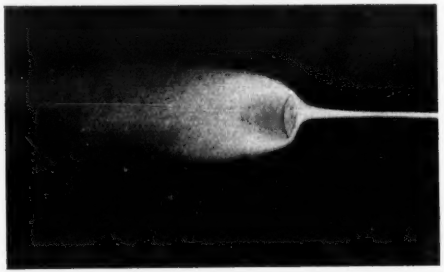


FIG. 7

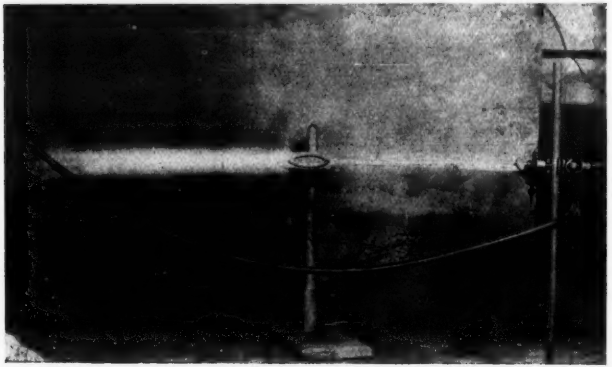


FIG. 8

FIG. 11

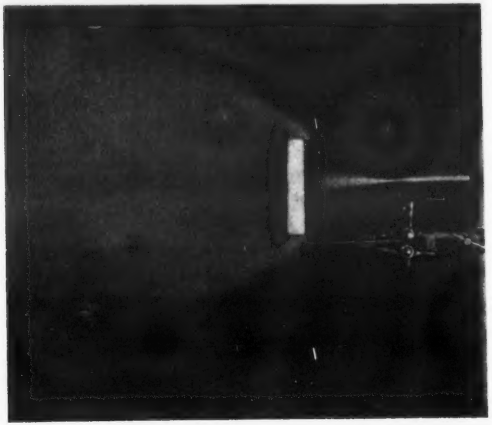


FIG. 9

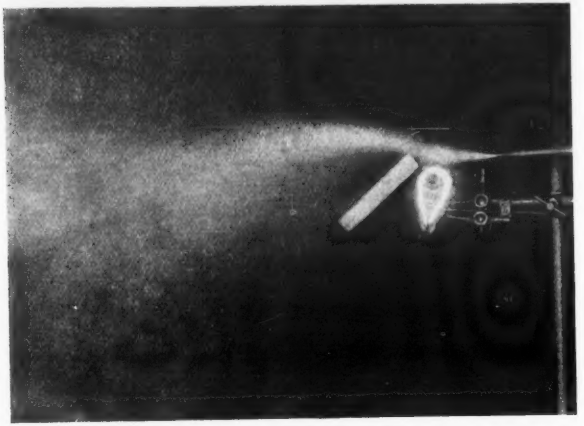


FIG. 10

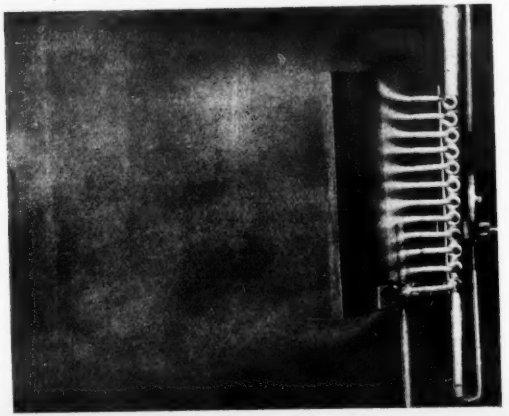


FIG. 11

FIG. 14

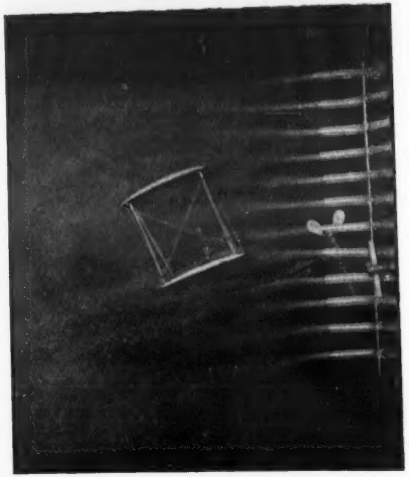


FIG. 12

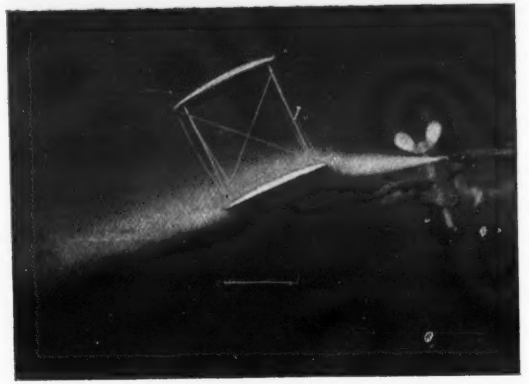


FIG. 13

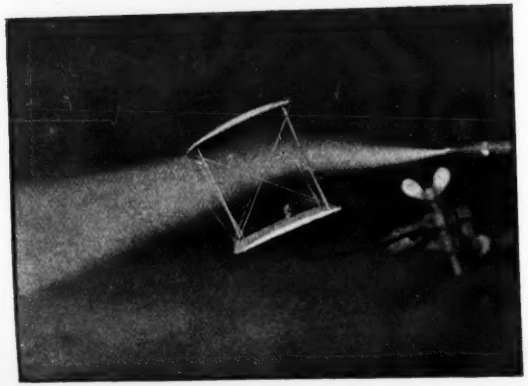


FIG. 14

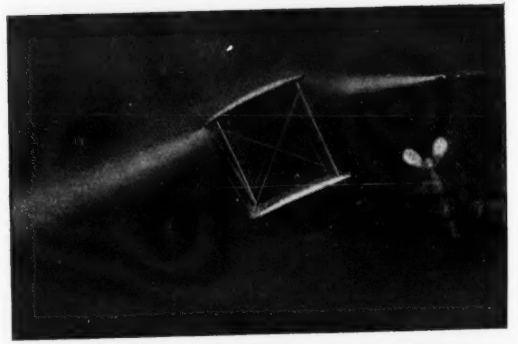


FIG. 15

Fig. 2 shows a stream-line which is initially just below (*i.e.* $\frac{1}{8}$ in.) the level of the rear edge of the same aerocurve when at an angle of 32°. The stream-line does not meet the plane but has a gentle downward momentum impressed upon it.

In Fig. 3 the stream-line is initially $1\frac{1}{4}$ in. below the top of the plane. The compression on the face of the plane, the downward momentum impressed upon the air, the eddying at the rear edge and the rush to neutralize the rarefaction at the back of the plane are well shown.

In Fig. 4 the jet is just level with the top edge of the plane. The stream-line divides, the lower portion travelling down the face of the plane and closely hugging it, the upper portion leaping clear of the plane and forming a surface of discontinuity and a series of vortices. The largest vortex always appeared to occupy the space immediately above the rear edge of the plane. A smaller vortex flowing in the reverse direction is to be seen immediately below the large one. The downward momentum impressed upon the air is again well shown, and it is clearly seen that the disturbance above the plane is very much greater than that below.

In Fig. 5 the jet is $\frac{7}{8}$ in. above the front edge of the aerocurve. The downward momentum is again well marked and the limited eddying and dispersion which take place are faintly shown.

In Fig. 6 the jet is $1\frac{5}{8}$ in. above the front edge of the plane. This is a better photograph than Fig. 5. The downward momentum and the "streamerlike" dispersion are very well shown.

Fig. 7 shows the surface of discontinuity formed by a pointed elliptical bar when set broadside to the current. The stream line divides, forms a surface of discontinuity, and the greater portion of it appears to reunite more or less at the centre. There is, however, an outer region of dispersion giving the stream line a "comet" effect.

In Fig. 8 the same bar is shown "edge on" to the wind. There is far less disturbance. The stream-line expands over the bar, contracts together again at the rear and then appears to expand again, probably due to the eddying of the wake.

Fig. 9 shows a rectangular sectioned bar at right angles to the wind. The surface of discontinuity formed is clearly shown.

In Fig. 10 the same bar is shown inclined, the stream line being level with the top edge of the bar. A similar effect is obtained to Fig. 4. The electric lamp in the line of vision forms no part of the photograph.

Fig. 11 shows the stream line flow on the under face of an inclined plane. In this case the plane is the rectangular bar of Figs. 9 and 10. Owing to the compression on this face some of the air escapes at the sides, so relieving the pressure. This is shown by the stream-lines changing their direction and flowing over the side edges. The inclination and, therefore, the rate of escape, appears to be greater at the front edge than at the back edge of the plane.

The flow of air about a biplane set at an angle of 24° is shown in Figs. 12, 13, 14 and 15. In Fig. 12 we have a number of smoke jets which mark at set intervals the air flowing over the planes. The air below the bottom plane is gently deflected downwards, the air between the planes is also curved round and given a downward momentum, while the air above is apparently not much deflected downwards until it is towards the rear of the plane. This effect is also shown in Figs. 5 and 6.

Fig. 13 shows a single and heavy jet passing over the lower plane. The stream line flows on either side of the plane and apparently does not form a well-defined surface of discontinuity on the back. On the contrary, the air flowing on the top side of the lower plane appears to hug the surface more closely than it would do if the top plane were absent.

Fig. 14 shows a stream-line flowing between the planes. The air is curved round approximately parallel to the planes and the rarefaction above the top plane appears to be felt after the air has left the planes, and assists in dispersing the smoke line. In Fig. 15 a stream-line is shown embracing the top plane.

All these photographs, with the exception of Fig. 7, are untouched. Fig. 7 has been strengthened and the background worked out.

MEMBERS' MACHINES: No. III.

THE CLARKE MONOPLANE

Mr. T. W. K. Clarke's new monoplane, which he has designed and built at his aeroplane works, is now completed, and ready for its trials, which will probably take place at Brooklands. In its design this machine presents several interesting departures from existing types, and possesses a number of improvements in constructive details.

Like Mr. Clarke's gliders and model flyers (on which subject he read a very complete Paper before the Society in May, 1908), his monoplane is tailless and has only a small stabilising and elevating surface in front; one of the principal advantages of this system, as Mr. Clarke has often pointed out, is that the smaller surface does not have to follow in or near the wake of the main surface, interference effects being thus greatly reduced. This arrangement, moreover, renders it possible to stay the main surface spars direct from the front of the frame, so as to relieve them from excessive bending stresses due to head resistance in flight; this is an object which cannot be easily attained in the usual type of monoplane with a tail surface in rear. From the accompanying drawings it will be noticed that the surfaces have "fair" ends in plan, so as to obviate to a great extent the formation of turbulent air eddies at the wing-tips, which is known to be the cause of so much loss of efficiency in the case of planes which have more or less square-ended surfaces. The extremities of the planes are also formed with a special shape and camber so as to conduce to the lateral stability of the machine. The position of the vertical steering rudder on top of the front surface is contrary to present practice in aeroplane design; it is certainly open to question whether in aeroplane design there are the same reasons for placing the rudder in rear as those which obtain in the design of ships.

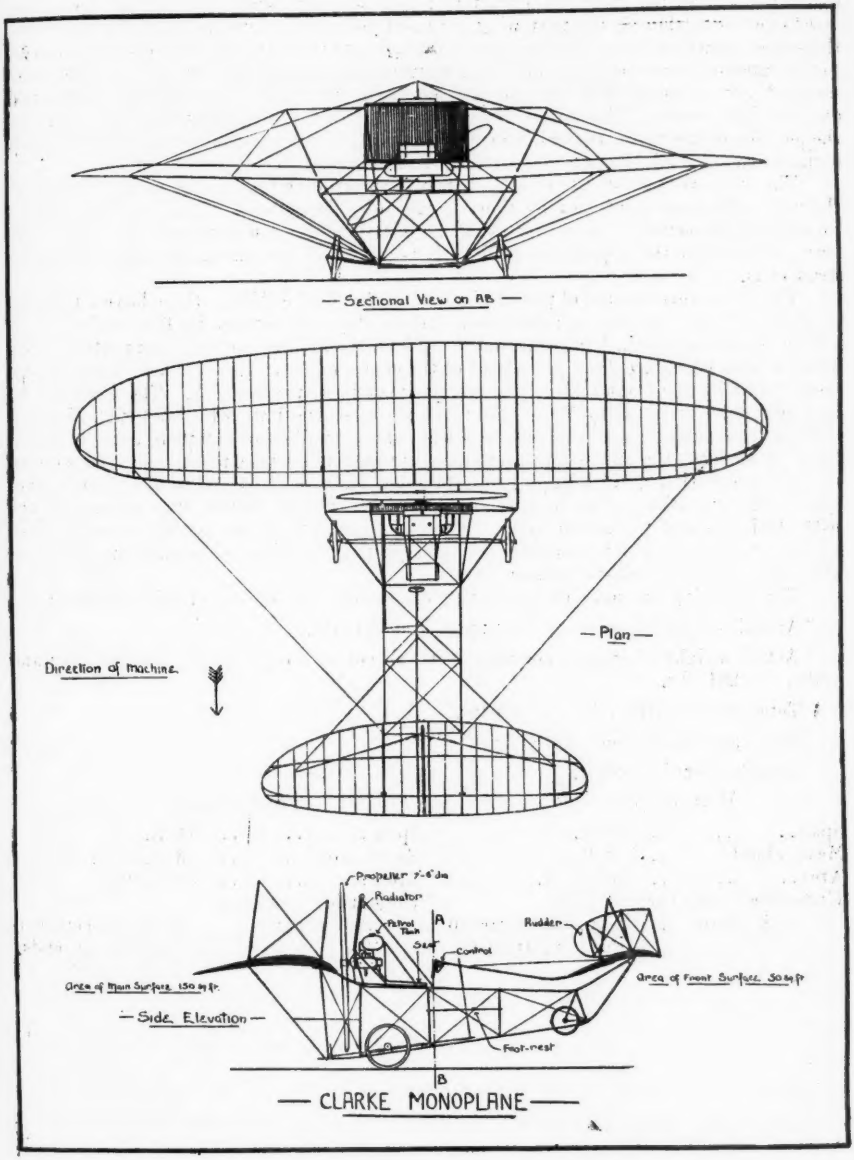
The two surfaces, which are both built up of I-section ash spars, and silver-spruce ribs, and covered with pegamoid fabric, are mounted at opposite ends of a rectangular lattice framework of English ash, the lower members of which form landing-skids. The main surface is attached to the frame by two duplex shackle fixings at the front main spar and one central fixing at the rear spar, from which two raking struts diverge downwards to the two bottom frame members. Both surfaces are quickly detached by releasing a few nuts.

The power plant consists of a 25—30 h.p. "Thames" engine, by The Thames Shipbuilding and Engineering Co., Ltd., having 4 opposed cylinders 4 in. by 4½ in. (the latter are made from Belleville boiler tubes); the radiator (Lamplough), and combined petrol and oil tank are supported up above, and the whole power unit, being mounted on independent bearers across the framework, is readily detachable. The engine bearers are prolonged forwards to carry the pilot's seat, and the rear bay of the frame is extended outwards at the top to give sufficient clearance to swing a 7 ft. 6 in. "Clarke" propeller, which is built up of Honduras mahogany and covered with unbleached linen, and which turns at 1100 to 1200 r.p.m., being direct coupled to the motor shaft.*

The 3 controls are combined in one small handwheel at the end of a flexible lever made of American elm; the front surface which acts both as stabiliser and elevator, is pivoted about its centre of pressure, and in its normal position is set up at a small positive angle to the main surface in rear. The elevator lever is flexible sideways, and carries near its end a vertical telescopic tube-arm, which is universally mounted and operates the wing-warping by means of a tubular shaft supported in bearings alongside the frame.

The vertical rudder in front is moved by rotating the handwheel to right or left, so as to take in and release the light running cable which passes to the rudder through

* In this connection it may be of interest to state that one of the "Clarke" propellers, which were recently tested by Vickers, Maxim, Ltd., on their new 110 ft. testing arm at their Barrow works, was found to have an efficiency of 71·8%. (This result was obtained with even over 40% slip, their apparatus, originally designed for propellers of dirigibles, being too large to allow any aeroplane propeller to rotate it at its proper flight speed.)



SCALE DRAWINGS OF THE CLARKE MONOPLANE

Bowden sheath leads fixed near the extremities of the front surface. The lateral movement of the lever is also designed to turn the rudder through a small angle, in order to compensate for the effect of the warping; that is to say, whenever the pilot pushes his lever over to starboard, the port wing is caused to assume a greater angle of incidence, thus slowing up that side of the machine, and tending to turn it to the left; owing, however, to the interconnection of the rudder and warping mechanisms, the rudder is at the same moment automatically put over to the left, and the machine is thereby maintained on a straight course. This action is similar to that of the Wright biplane, but owing to the position of the rudder in the Clarke machine being in front instead of in rear of the main surface, the method of operation is somewhat different.

The framework struts are of ash, shaped to stream-line form and tapering slightly to the ends, which are reinforced by short ferrules of weldless steel tubing, specially drawn to stream-line section. As is now usual, no wire-strainers are employed, the stay-wires being strained by the adjustment of light U bolts, which are passed through slots in the strut ends.

The framework ties are of plated piano wire 12 and 16 S.W.G.; these have a tenacity of about 120 tons per sq. in.; the main surface stays are formed by flat steel strips of a lower tensile strength, $\frac{3}{4}$ in. wide and 20 S.W.G. thick. The machine is supported on two 24 in. wheels which are fixed just ahead of the centre of gravity. A smaller wheel is also mounted below the front surface, though this may be dispensed with. These wheels are of a new type, designed by Mr. Clarke; the plain-bearing hub, which is kept full of oil, is made from solid-drawn tube, and each rim is built up of three complete turns of a thin band of hickory, the spoke nipples passing through the whole thickness; the wooden rim is bound with a spiral wrapping of unbleached linen, and covered with a thick leather tyre laced in position. This form of wheel is several pounds lighter than the usual type with steel rims and pneumatic tyres. The two larger wheels are carried at each end of a resilient ash axle, which acts as a shock-absorber, and is also free to take up sidestress, under the control of elastic tension bands.

The following are some of the leading dimensions and details of this machine:—

Actual weight of machine "stripped" = 280 lbs.

Actual weight of engine, complete with all connections, but without radiator and tanks, = 201 lbs.

Total weight with pilot = 750 lbs.

Load per square foot = $3\frac{3}{4}$ lbs.

Length overall = 20 ft.

Main Surface

Span	30 ft.
Mean chord	5 ft.
Area	150 sq. ft.
Underside camber at $\frac{1}{3}$ chord	3 in. at centre to $1\frac{7}{8}$ in. at ends.

Front Surface

Span	14 ft.
Mean chord	3 ft. 6 in.
Area	50 sq. ft.
Underside camber at $\frac{1}{3}$ chord	$2\frac{1}{4}$ in. at centre to $1\frac{1}{8}$ in. at ends.

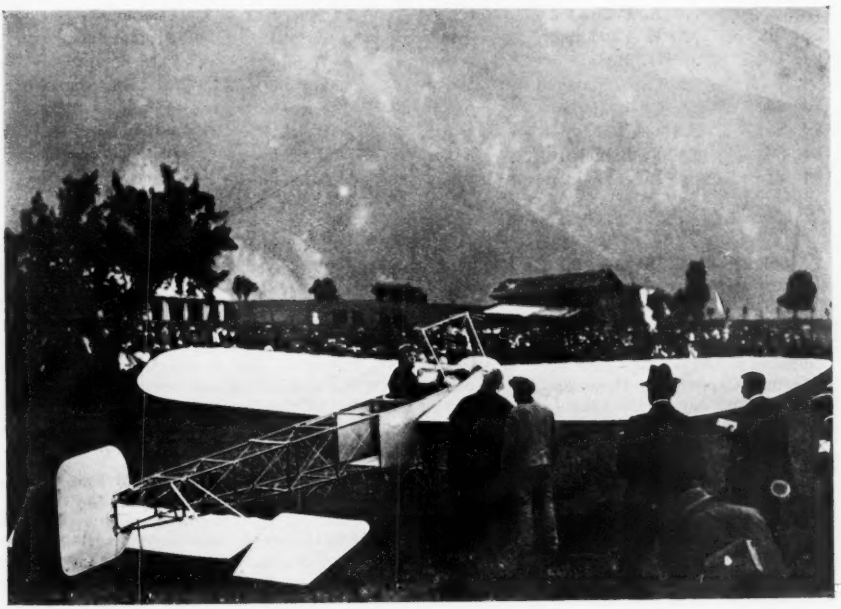
H. F. LLOYD.

NOTES

The Death of M. Chavez. The whole civilized world has joined in mourning for M. Georges Chavez, the young Peruvian, who, at the age of 23, being the first man to cross the Alps by air, has won thereby immortal fame and death. Prizes were offered by the Milan Aviation Committee for a flight from Brigue in Switzerland over the Simplon Pass to their city—a distance of 94 miles, which meant rising to a minimum height of 6,600 feet above sea-level, and flying over miles where cross currents and eddies met on all sides and safe descent was impossible.

M. Chavez starting at 1.30 p.m. on Friday, September 23rd, reached Domodossola, 25 miles away, on the route to Milan 41 minutes later. Here dazed and numbed with cold he descended, making a bad landing and smashing the machine. The wings of his Blèriot monoplane are said to have collapsed about 30 feet off the ground; at any rate, in regaining the earth, he broke both legs and sustained other serious injuries. He lingered until the following Tuesday, and then died.

Such, very briefly, is the story of what is perhaps the most stirring event in the history of aerial navigation. All human progress—indeed all human existence—is summed up in the spectacle of the pitiful little contrivance of wood, metal and canvas, wind-tossed and buffetted, flitting through the gigantic gorges like a frightened bird, only to fall broken and wounded when the passage is achieved, and the road marked out for ever. Therefore we salute Chavez, the air-conqueror—Chavez, who opened the air-way of the Alps—Chavez, who is dead.



CHAVEZ ABOUT TO START ON HIS TRANS-ALPINE FLIGHT

Fatal Accidents of the Year. There has been a regrettably large number of fatal accidents during the year in aviation, and unfortunately the exact causes of most of them are unknown. Apart from fatalities, numberless mishaps of a less serious nature have occurred also generally from an unknown cause. The usual method of reporting accidents is "—while flying at a considerable height fell with his aeroplane. The machine

was broken to pieces, the aviator is slightly (or severely) injured." In this way accidents, which might help progress by showing where faults lie, are rendered worse then useless. It should be the business of aeronautical authorities in each country to investigate every serious accident and publish a report as soon afterwards as possible for the benefit of all concerned, giving the type of machine, direction of wind, direction of machine, nature of ground, &c., in fact the full details. As far as can be judged, a large number of accidents have occurred from lack of engineering skill and strength in construction.

Date	Name	Nationality	Machine	Place
Jan. 4 ..	L. Delagrange	French	Blèriot	Pau
April 2 ..	H. Le Blon	French	Blèriot	San Sebastian
May 13	H. Michelin	French	Antoinette	Lyons
June 18	T. Robl	German	Aviatik	Stettin
July 4 ..	C. Wachter	French	Antoinette	Rheims
July 10	D. Kinet	Belgian	Farman	Ghent
July 12	Hon. C. S. Rolls	English	Wright	Bournemouth
Aug. 3 ..	N. Kinet	Belgian	Farman	Liège
Aug. 20..	Lt. Vivaldi Pasqua	Italian	Farman	Nr. Magliano
Aug. 27..	C. van Maasdyk	Dutch	Sommer	Amsterdam
Sept. 23	G. Chavez	Peruvian	Blèriot	Domodossola
Sept. 25	E. Poillot	French	Savery	Chartres
Sept. 28	E. Plochmann	German	Aviatik	Mulhausen
Oct. 1 ..	H. Haas	German	Wright	Nr. Treves
Oct. 7 ..	Capt. Matsievich	Russian	Farman	St. Petersburg
Oct. 23	Capt. Madiot	French	Farman	Douai
Oct. 25	Lieut. Mente	German	Wright	Magdeburg
Oct. 26	F. Blanchard	French	Blèriot	Issy-les-Moulineaux
Oct. 27	Lieut. Saglietti	Italian	Sommer	Nr. Rome

Colonel J. E. Capper, C.B., R.E. The retirement of Colonel Capper from the command of the Balloon School will be greatly regretted by all those who have followed the work of that sorely-handicapped department of the British Army. It is not too much to say that Colonel Capper has achieved miracles with little encouragement and less funds, and has tided British military aeronautics over a most critical period in its history when the slightest slackening of the command would perhaps have been fatal. How much the nation owes to the unremitting labours of Colonel Capper only those who have worked under him at Farnborough can tell, but the high state of efficiency of the school, the perfect organisation of the factory, and the vast amount of work accomplished within the limits of the meagre supplies placed at his disposal, are ample evidence that military aeronautics has lost one who cannot easily be replaced.

The outstanding features that to the public have marked his four years' rule at Farnborough have been the building of three dirigibles for the Army, the splendid voyages of the "Beta" from Farnborough to London and back on the 4th of June and the 12th of July in this year, and the participation of this latter most successful dirigible in the recent manœuvres. His achievements, however, are not to be gauged by spectacular display; his true work has been beneath the surface, but it has been permanent. His predecessors had the high honour of inaugurating and maintaining British military aeronautics: Colonel Capper has developed and established it.

Colonel J. E. Capper, C.B., R.E., was born in 1861 and received his commission in the Royal Engineers in 1880. He has served in India and Burma and took part in the Tirah Campaign (1898) and throughout the South African War. For his distinguished services in Africa he received the brevet of Lieut-Colonel and the C.B., and on the retirement of Colonel Templer from the superintendency of the Balloon Factory in 1906 he was appointed to the post, which included the command of the Balloon School. Owing to the great increase of work, these appointments have now been separated, and Colonel Capper is succeeded by Mr. Mervyn O'Gorman, who recently took over the charge of the Balloon Factory, and Major Sir Alexander Bannerman, Bart., the new Commandant of the Balloon School.

Mr. LUNARDI,
Taken from the Life, by Torond,
and Publiſhed, as the Act directs,
1784.

A newly-discovered portrait of Vincent Lunardi, who made the first balloon voyage in England from the Artillery Ground, Chelsea, to a field in the parish of Standon, near Ware, on 15th September, 1784.

NEW BOOKS AND PUBLICATIONS

*Aëronautical Classics: No. 4.—The Aerial Ship. Francesco Lana. London: Aëronautical Society of Great Britain. 1910. 1s. n.

L'Aëroplane pour Tous. Lelasseux and Marque. Paris: Librairie Aéronautique. 1910. 22nd Ed. pp. 159. 2 francs.

*Notable Flying Men. Compiled by the staff of "The Motor." London: Temple Press, 1910 pp. 88. 6d. n.

Les Aeroplanes: Considerations Theoriques. Paul Raybaud. Paris: F. L. Vivien. 1910. pp. 24. 1 franc.

*The Aviator's Companion. Dick and Henry Farman. London: Mills and Boon. 1910. pp. 102. 2s. 6d. n.

*Aerial Navigation. Frederick Walker. London: Crosby Lockwood. 1910. 2nd Ed. pp. 164. 5s. n.

Monographies D'Aviation: No. 8.—Les Ailes des Aéroplanes. pp. 16. No. 9.—Les Biplans Farman. pp. 16. A. Bracke. Paris: Librairie Aéronautique. 1910. 75 centimes each.

Fifth Annual Report of the Meteorological Committee. London: H. M. Stationery Office. 1910. pp. 147. 1s. 10d. n.

*La Resistance de L'Air. G. Eiffel. Paris: Librairie Aéronautique. 1910. pp. 256. 5 francs.

*L'Equilibre des Aeroplanes. R. Desmons. Paris: F. L. Vivien. 1910. pp. 51. 1.50 francs.

Equilibre, Centrage and Classification des Aeroplanes. R. Saulnier. Paris: Librairie Aéronautique. 1910. pp. 58. 3 francs.

*Flying Machines: Practice and Design. Rankin Kennedy. London: Technical Publishing Company. 1909. pp. 158. 5s. 6d. n.

Sixieme Reunion de la C.I.A.S. à Monaco, 1909: Procès-Verbaux. Strasbourg: Du Mont Schauberg. 1910. pp. XIV. + 161.

Aerial Propellers and some Test Results. C. E. Larard, M.I.Mech.E., and R. O. Boswall, B.Sc. (Reprinted from "Engineering," September 2, 1910.) London: "Engineering." 1910. pp. 11.

An Aeronautical Model for Experimental Work. C. E. Larard, M.I.Mech.E., and R. O. Boswall, B.Sc. (Reprinted from "Engineering," December 10, 1910). London: "Engineering." 1910. pp. 15.

*The Report of the Advisory Committee for Aeronautics for the Year, 1909-10. London: H. M. Stationery Office, 1910. pp. 191. 8s. 5d. n.

*Formulaire pour la Construction des Aeroplanes. A. Guironnet, Ing., E.C.P. Paris: Librairie Aéronautique. 1910. pp. 163. 3 francs.

L'Aéroplane etudie et calcule par les Mathematiques Elementaires. Capitaine du Génie Duchêne. Paris: Chapelot. 1910. pp. 306. 5 francs, 50.

The Problem of Flight: A Text Book of Aerial Engineering. Herbert Chatley, B.Sc. London: Chas. Griffin. 1910. 2nd Ed. 10s. 6d. n.

The Aero Manual. Compiled by the staff of "The Motor." London: Temple Press. 1910. 2nd Ed. 1s. 6d. n.

L'Aviation de Demain. F. Ernoult, Inq. Paris: Librairie Aéronautique, 1910. pp. 88. 3 francs.

*Notice of this book will be found in the present number.

REVIEWS

Report of the Advisory Committee for Aeronautics. 1909—1910. (London: H. M. Stationery Office, 1910, pp. 191 ; 8s. 5d. n.)

This first Report of the recently constituted Advisory Committee is an interesting one, and it is evident that, considering the difficulties in starting investigations of this description, good work has been done during the year the committee has been in existence.

The Report may be divided into three parts, viz. :—

I. An account of the apparatus used.

II. Miscellaneous, subsidiary reports and memoranda.

III. Summaries of papers, etc., which have appeared from time to time in the aeronautical and engineering press.

I. THE APPARATUS IN USE

The apparatus designed and constructed under the supervision of the Committee consists of a wind tunnel, a whirling table, experimental wind towers, motor testing apparatus, etc.

The Wind Tunnel is of the type familiar to aeronauts ; cross section 4 ft. by 4 ft., length 20 ft., and a steady flow of air, up to a velocity of 30 ft. per sec., is said to be maintained. The tunnel appears to be on a very small scale, and in this respect compares unfavourably with the one constructed by the German Society for the study of Airships, which has a diameter of 3 metres (10 ft.) and can test models up to 16 inches in diameter. With a 4 ft. by 4 ft. tunnel, 6 inches would appear to be about the largest suitable diameter, and it is very doubtful whether the results obtained from such small models, are satisfactory. It is to be hoped that a larger tunnel will be built later on, circular in section instead of square and capable of taking models up to 2 ft. in diameter. As regards the flow of the current, it might be worth while considering the type of fan used by Amans (see " Etudes Expérimentales sur les Zooptères ") as this seems to have given a very steady, horizontal flow.

The Whirling Table is of the single arm type, with a 30 ft. radius ; the whole machine being worked in a shed 80 ft. by 80 ft. The Committee does not seem to favour this class of apparatus, and no doubt the single-arm type is somewhat unsatisfactory, but a really well-designed, double-arm table, say 60 ft. in diameter, like that used by Prof. Langley ought to give very good results when used in a shed of suitable dimensions. It is to be hoped that something of this kind will be tried later on, especially as the use of two models one on each arm, greatly facilitates accurate work.

The Manumetric method of testing which was used some little time ago by Dr. Stanton, D.Sc., seems to have been abandoned. This is unfortunate, as while not very accurate, it gives a great deal of very useful information regarding the pressures at given points on a model. It is also particularly useful for finding the true centre of pressure, which can be calculated when the details of the pressures above mentioned are known.

As regards the *Experimental Towers* these will no doubt be found useful in some ways, but it is to be hoped that too much reliance will not be placed on tests " in the wind," as the results obtained in this way, are very unsatisfactory. The wind as is well known, varies rapidly not only in velocity, but also in *direction*, and while it may be possible to get the velocity with a fair amount of accuracy, the finding of the real direction at any given instant, is an extremely difficult matter. This combined with the disturbances caused by the girders, beams, etc., of which the towers are constructed, make such tests of very little value and it is to be hoped that no very great amount of work of this kind will be carried out.

Other apparatus.—A plant for testing motors, and some fabric-testing machines have been constructed ; these no doubt will prove useful.

II. MISCELLANEOUS SUBSIDIARY REPORTS, ETC.

No. 2. *Memorandum on general questions, etc., by Mr. A. Mallock, F.R.S.* This treats in a general manner with the lift and drift of surfaces, surface friction and certain special questions relating to balloons, and heavier-than-air machines. Figs. 1, 2, and 3 show typical curves of lift, drift, and $\frac{\text{lift}}{\text{drift}}$ from the author's experiments. The results for flat surfaces agree with those of other experimenters, but 7 to 10 appears to be a very small value of $\frac{\text{lift}}{\text{drift}}$ or curved surfaces, as Mr. H. Phillips got about 20, and 14 or 15 is a not unusual value for a good design. It is not quite clear what surfaces are represented but r_x is clearly not $= 0$ when

$\theta = o$ as shown in Fig. I. unless a theoretically thin plane surface is meant. For real surfaces, whether plain or curved r_x has often quite a considerable value, largely due to the "form" of the surface, and it is most desirable that this should be thoroughly understood, especially when the question of skin friction is under consideration. As regards curved surfaces, the value $\frac{\text{lift}}{\text{dritt}} = o$ occurs when $\theta =$ a negative angle; for example Lilienthal's surface shown in Plan IV. "Der Vogelflug," had $\theta = -9°$; and this might have been brought out more clearly.

The fluctuations at the angle of about 40° do not appear to be of much importance as no well-designed machine would carry its sustainers at such a steep angle, except perhaps for a few seconds when starting or alighting. It is doubtful whether the proposed system of measuring surface friction (ends of models in still air) would give satisfactory results; the difficulty of making accurate tests by this method is obvious.

The author does not seem to be aware of Zahm's experiments on rods—(see "Navigating the Air," Aero Club of New York).

No. 4. Recent researches, etc., by Dr. T. E. Stanton, D.Sc. This is an interesting paper and discusses, generally, surface friction, the air forces acting on thin plates, and the centre of pressure of the same. Omitting for the present the question of surface friction, a few notes on the other two points seem desirable. The author is apparently much opposed to the use of a whirling table, but it must be recollected that this class of apparatus has so far never really had a fair chance. As explained before, there does not seem to be any reason why a large diameter, double-armed table, in a suitable shed, should not work well and it would certainly be a very useful check on the wind tunnel system, which latter is a very difficult one to carry out successfully. As regards the Dines experiments it is not quite clear what the real shape of the planes was; they appear to have been triangular in section, and if this was the case the discrepancies between Mr. Dines' results and those of other experimenters can be accounted for.

The manumetric experiments of Finzi and Soldati are interesting; one very peculiar result is that at 5° the flat surface gave a higher ratio of lift to drift, than the curved one, which is contrary to the experience of most other observers.

As regards the centre of pressure experiments, as the author points out, there is considerable divergence of opinion as to the real position of this point, and further experiment, especially at small angles, is very much required. The thickness of the surfaces seems to have a good deal of influence on the results; it is doubtful whether sufficient attention has been paid to this very important matter.

No. 15 Part I. Notes on the Resistance of Planes, etc., by Mr. F. W. Lanchester. In this paper Mr. Lanchester deals with the resistance of normal planes, ichthyoid bodies, and the question of skin friction. A useful table of the values of K (N.B.—Langley's value $= \cdot00166 = \frac{1}{600}$ as a mean) is given and the necessity for further experiments on this subject pointed out, as the results at present available differ very considerably. Possibly this is partly due to the difference of thickness between the surfaces used; a plate 1 ft. in diameter and one 3 ft. in diameter, should be similar in every respect, as it is only when the stream lines are similar that a correct comparison between the pressures obtained can be made.

As regards the ichthyoid bodies the author points out that if they are well formed, the whole resistance is practically speaking equal to the skin friction resistance. This may be the case occasionally, but it must not be taken as a definite rule. For instance body No. 2, in the Report No. 17 by Dr. Stanton and Mr. Bairstow is usually considered to be a good type, but if we take $\xi = \cdot00455v^2$ for water (see p. 71) the frictional force

$$= \frac{10\cdot87 \text{ sq. in.}}{144} \times \cdot00455 \times 1\cdot78^2 = \cdot0011 \text{ lbs. nearly.}$$

Since the total resistance was ·00255 lbs. the "form resistance" was ·00145 lbs.—quite a considerable amount.

As regards skin friction, both Mr. Lanchester and Dr. Stanton follow more or less on the lines laid down by Froude (water) and Zahm (air) and practically speaking, assume that when thin plates or boards are used for the tests, the "form resistance" = O and that the total resistance is that due to skin friction alone. This may be so, but if such is the case it is clear that the thickness of the plates must be exceedingly small. Consider for example the plates used by Langley ($\frac{1}{8}$ in. by 12 in. by 12 in.) and Lilienthal ($\frac{1}{6}$ in. by 72 in. by 10 in. mean): assuming the double surface coefficient = ·015 (see p. 26) we get

	Total Resistance	Frictional Resistance
Langley	$\cdot1 \times KSV^2$	$\cdot015KSV^2$
Lilienthal	$\cdot083KSV^2$	$\cdot015KSV^2$

So that the "form resistances" were from 5 to 6 times as great as the frictional ones.

No doubt in the case of Froude's experiments the sharp prow and stern pieces diminished the "form resistance" very considerably, especially as the plates or boards used were very thin, but it is by no means certain that this resistance was entirely eliminated, especially as regards the short 2 ft. boards. In these the ratio of thickness to length was $\frac{3}{16}$ inch to 2 ft., or about $\frac{1}{130}$, not very much greater than the ratio of Langley's plates $\frac{1}{96}$. In the Zahm experiments "form resistance" was allowed for in calculating the skin friction, but the results do not seem to be very convincing. The first series with the wind shields could hardly be expected to give good results, as the shields themselves must have considerably interfered with the flow of the air, while in the second series the system of deducting the prow and stern resistances from the total pressures recorded, does not seem to be quite reliable, when the boards were so dissimilar in shape. A point in connection with the Froude experiments, viz., that the boards 19 in. deep had apparently only $1\frac{1}{2}$ inches of water over them, seems to have escaped notice. In view of the remarks made in Report No. 17, note p. 72, the matter appears to be important and to require further investigation.

As regards the experiments of Stockalper and Riedler, quoted by Dr. Stanton, the value of ξ obtained does not appear to be very trustworthy; the mains were apparently of the ordinary rough surface type, and the resistance of bends, etc., does not seem to have been allowed for.

The question of skin friction undoubtedly requires much more thorough investigation than it has hitherto received, and it is to be hoped that the Laboratory Committee of the Aeronautical Society will carry out experiments to ascertain the real value of the frictional co-efficient as soon as funds are available for the work.

Report No. 16. *Notes on Experiments by Mr. R. E. Froude. By Mr. A. Mallock, F.R.S.* In this, some interesting particulars are given of Mr. Froude's experiments on the centre of pressure, lift, drift, etc. The principal point brought out is that the method of calculating the resistances and lateral forces, on the assumption that the pressure on the rear surface of a body is uniform and equal to that of the fluid at a distance, is erroneous, and that it is absolutely necessary to take into consideration the *actual distribution* of the fluid, on *both sides of the body.*

No. 17. *Report of Experiments on the resistance of balloon models, etc. By Dr. T. Stanton, F.R.S. and D.Sc., and Mr. Bairstow.* This paper gives some interesting results as to the resistance of certain balloon shaped models moving in water at slow speeds, and incidentally gives (although the details are not calculated out) the ratios.

$$\frac{1}{\delta} = \frac{\text{Resistance of the body}}{\text{Resistance of plane of the same max. cross section}}$$

Assuming that for water $P_{90} = 780 \times \cdot 00166 KSV^2$

(see footnote, p. 71) the results are as follows:—

	$\frac{1}{\delta}$
No. 1 Model	$\frac{1}{8 \cdot 96}$
No. 2 Model	$\frac{1}{8 \cdot 85}$
No. 3 Model	$\frac{1}{7 \cdot 81}$
No. 4 Model	$\frac{1}{4 \cdot 20}$

These results agree fairly well with those of Wellner.

It is to be hoped that the experiments will be repeated in a much larger tank. The models had only a maximum diameter of 1 in., and as the depth of the water was only 7 inches, the results cannot be considered as more than approximate. The very important note on p. 72 on the effect of the proximity of the surface of the water, is deserving of special attention, as it is quite clear from the details given that the models must be deeply submerged if satisfactory results are to be obtained.

No. 10. *Preliminary Report on the weights and H.P. of petrol motors, etc., by Mr. F. W. Lanchester.* In this paper the weights of Aeronautical motors are examined and certain rules laid down as to what should, and should not, be considered as part of the weight, when estimating the weight per H.P. Mr. Lanchester points out that fuel is also a very important item of the weight, and shows how it should be allowed for when the merits of any particular motor are under discussion. The author of this review suggests that the system proposed by him (see "Royal Engineer Journal," 1897) of including so many hours fuel consumption, say

A standard	10 hours
B standard	50 hours
C standard	100 hours

when calculating the weight per H.P. might be adopted with advantage.

No. 9. *Report on Wind Structure, etc., by Dr. W. N. Shaw, F.R.S.* This is one of the most interesting of all the reports, as the general system of motion of the atmosphere is clearly explained. The table of wind velocities on land, p. 113, will be found very useful for ascertaining the approximate speed of the winds in a practical way.

No. 14. *Memorandum on the Flying Fish, etc., by Mr. Mallock, F.B.S.* This paper gives an account of the author's observations, and should be read in conjunction with Mr. Shadbolt's article on this subject in the AËRONAUTICAL JOURNAL for October, 1908. The author points out the large weight carried per sq. ft. of supporting surface by the flying fish and it is certainly very remarkable that such a small fish should carry nearly the same weight as a large bird like the albatross. As regards the muscular power exerted by birds, it is doubtful whether it is in proportion to the weight. Many of the large birds spend most of their time in "sailing" which does not require muscular power, and as far as can be ascertained at present, these sailing birds have if anything proportionally less weight of breast muscle than the smaller birds. The whole subject is a very difficult one; most of the information now available will, it is hoped, appear in the forthcoming Report of the "Bird Construction Committee" of the Aëronautical Society.

There are many other interesting papers, which however cannot for want of space be discussed here. Turning to

III. THE SUMMARIES

the most important is: —

No. 18. *Summary of papers relating to the Stability of Airships and Aeroplanes by the Secretary.* This is a very useful paper, and gives a very good description of the Crocco (dirigible) and Soreau and Ferber (aeroplane) theories of stability. The theory of the dirigible is not, however, nearly of so much interest as heavier-than-air machines are, but it is perhaps desirable to point out some of the difficulties in connection with the Soreau and Ferber theories of longitudinal stability. The Soreau system is based upon the idea that an "equivalent plane" can be used to replace a curved surface, and also that the Joessel formula for centre of pressure is applicable to curved surfaces. Now an "equivalent surface" can be found as regards the amount of the air force acting on a curved surface, but it does not necessarily follow that the true line of action of the force will also be represented. This is a very serious defect in the theory, as the *line of action* of the force plays a most important part in the longitudinal stability question and the assumption which is apparently made that the force acts perpendicularly to the equivalent plane may lead to very considerable error.

As regards the centre of pressure of curved surfaces, this point does not lie on the curve itself as is so often assumed, but in the hollow (see AËRONAUTICAL JOURNAL for January, 1910), and Joessel's formula cannot safely be used in cases of this kind.

The Ferber theory is clearly explained; like Soreau's it is open to the objection that the lines of action of the forces cannot be taken as perpendicular to the imaginary planes.

The whole subject of longitudinal stability is a very difficult one, and is best treated by first testing, experimentally, the sustaining part of a machine, for amount, line of action, and centre of pressure of the air force, and then carrying out similar tests for the body of the apparatus. From these data, the amount, line of action, and centre of pressure of the resultant air force can be found and with this information the whole question can be treated as explained in the summary of the subject published by the author of this review in the AËRONAUTICAL JOURNAL for January, 1910. The great advantage of this method of treating the question is that it shows clearly the definite relation which must exist between the sustaining surfaces, and the body, in order to ensure longitudinal stability. The body of a bird for instance is not designed by chance, it is on the contrary designed to suit the particular style of wing with which the bird is equipped and any serious deviation from the true design will completely ruin the bird's power of balancing itself. The question of longitudinal stability is of enormous importance, the whole future of flight depends upon its successful investigation, and it is to be hoped that both the Aëronautical Society and the Advisory Committee will carry out the necessary experiments in connection with it at an early date.

Other Summaries, etc. There are many other interesting reports, summaries, and abstracts which will well repay perusal. Most of the abstracts are of course well known to readers of the Journal, but they are well summarised, and will be found useful by those who have not time to study the original papers.

J. D. FULLERTON,
Col. R.E. (ret.).

La Résistance de l'Air: examen des formules et des expériences. By G. Eiffel. (Paris: Dunod and Pinat, 1910. pp. 258. 5 francs 50.)

This is a very interesting book and will be read with advantage by all who are looking for the most reliable information on the subject with which it deals. In it M. Eiffel has brought together an account of the more important series of observations and experiments that have been made during the last forty years, he has given a description of the methods and apparatus used, and tables showing the results obtained.

There are three practical methods of working: (1) By moving the body in a circle through still air; (2) by moving the body in a straight line through still air; (3) by fixing the body in a current of air produced by a fan driven by steam or by an electric current. There are practical difficulties connected with all these methods; No. 2 is perhaps the best, but working in the open with either (No. 1) or (No. 2) the difficulty is to obtain still air, and No. 1 worked in a closed-in space affords the almost unsurpassable difficulty of avoiding or allowing for the eddy that is soon set up by the apparatus itself.

In classifying the results, M. Eiffel discusses the case of normal exposure for plates of various shapes, the case of exposure at various angles, and the case of curved plates and bodies, and it must be confessed that the results obtained by various experimenters are by no means consistent. For engineers, who have to deal with the action of the wind on bridges and similar structures, the pressure per square foot or per square metre on a body exposed normally is the most important constant, and happily the value of this is known with an error that can hardly reach 5 per cent. for the ordinary range of wind velocity. The Meteorological Office, for the purpose of changing velocity into pressure, or *vice versa*, has long used the relation $P = \cdot 003v^2$, where P is the pressure in lbs. per square foot on a square plate of moderate area, v the velocity in miles per hour, and average conditions as to temperature and barometric pressure are assumed. This value was founded on experiments made on a large whirling machine at Hersham subsequently to those referred to by M. Eiffel, as it was found that the earlier experiments had given too high a constant owing to the proximity of the fixed part of the apparatus. The value so obtained has been confirmed by M. Eiffel himself by experiments on his well-known tower (method 2) and also by Dr. Stanton at the National Physical Laboratory (method 3), and it is extremely improbable that any subsequent experiments will seriously alter it. It is generally agreed that the whole pressure is very nearly proportional to the extent of the surface exposed for similarly shaped plates, but there is still some doubt whether this rule is exact, and if not, in which way it departs from exact proportionality.

For those interested in aviation the results obtained in the case of flat or curved plates exposed to the wind at various angles are the more interesting. The subject is so complex and the different combinations between the shape of the plate and the angle of inclination are so numerous that it is impossible to enter much into the question in a short notice of M. Eiffel's book. The very curious excrescence at the angle of 35° on the curve showing the normal pressure upon a foot square plate, that I obtained at Hersham in 1888, and for many years hardly believed in, has been confirmed by M. Eiffel. His diagrams showing the normal, horizontal and vertical pressures upon a curved vane are very striking, and show the great advantage of this form, in so far as merely lifting purposes are concerned, over the flat form. But with regard to stability nothing can be said from this form of experiment, and it seems to me likely that when used in a flying machine the extra lift may be very dearly paid for in a loss of stability. It is much to be hoped that M. Eiffel's new plan may prove successful, and enable him to carry out more experiments on the many points that require elucidation. It is easy to criticise and find objections to any method, but it is only those who have worked at the subject who know how many practical difficulties have to be met, and how numerous are the pitfalls that await the most careful experimenters.—W. H. Dines.

"Formulaire pour la Construction des Aeroplanes." Par A. Guironnet, Ingénieur des Arts et Manufactures. (Paris: Librairie Aéronautique, 1910, pp. 158. 3 francs.)

This interesting little work deals chiefly with the mathematics of the aeroplane, and forms a fairly complete compilation of aeronautical formulæ derived from most of the best known authorities, though the work of the British School scarcely appears to receive adequate recognition. An improvement might perhaps be effected in a new edition by omitting a good deal of unnecessary matter and enlarging the scope of other subjects, so as to bring the whole up to date.

In Chapter V. is included a description of various woods and their properties; many of these are but seldom employed in aeroplane construction, while other useful kinds of timber, such as Canadian silver spruce, are not referred to.

The tables at the end, especially that of French and English equivalents, would be of more value if they were not marred by a number of clerical errors. The five chapters are, however, well arranged, the references are clearly given, and the book contains much useful information.

—H. F. L.

L'Equilibre des Aeroplanes. By R. Desmons. (Paris: F. L. Vivien, 1910, pp. 50. 1 franc 50.)

This little work deserves a place in every aeronautical library. M. Desmons treats his subject with a freshness and simplicity which is most attractive and is not often met with in treatises of this nature.

An effective use is made of diagrams and mathematical demonstrations, which adds greatly to the value of the work.

In the opening chapter the various means of obtaining stability used by birds are set forth and analysed, and the author then reviews the various mechanical solutions of the stability problem in use at the date of his book. He is very severe on the longitudinal stabilising system employed until recently by Voisin Frères and their school, namely, a fixed tail and a movable forward elevator, and must derive considerable satisfaction from the fact that since the publication of his work his criticisms have been justified by the abandonment of the forward elevator on the Voisin, Wright, and other machines.

M. Desmons advocates the use of wings with a variable angle of incidence in combination with a similarly movable tail. He calls attention to the necessity for taking account of the travel of the centre of pressure of the wings at different angles of incidence. He favours some form of automatic control of the stabilising system, and briefly reviews the gyroscope and the pendulum. It is to be hoped that M. Desmons will continue his investigations into those points which he raises, which merit more extended treatment. There are some obvious printer's errors in the book.—B. G. C.

Etude sur l'Equilibre Longitudinal et la Courbure des Surfaces Portantes des Aeroplanes. By R. Arnoux. (Paris: F. L. Vivien, 1910. pp. 16. 1 franc 50.)

Readers of the "Aeronautical Classics" will be familiar with Sir George Cayley's reference to the dihedral angle as a means of obtaining lateral stability, and with the fact that he rejected it as a means of obtaining longitudinal stability, for the reason that, as he puts it, "the sheet . . . must present a slightly concave surface in a small angle with the current." He was not prepared to sacrifice, in order to obtain longitudinal stability, the enhanced lift obtained by mounting curved planes with their concavity downwards, and in this course he has been followed by most experimenters since his time. M. René Arnoux, however, in this little work, comes forward boldly and proposes the dihedral angle for longitudinal stability. In other words he counsels mounting supporting surfaces with their concavity *upwards*. He does not ignore the fact that much lifting power would thus be sacrificed, but considers that stability should have first consideration. Few will be prepared to contest this view, but it seems doubtful whether the solution of M. Arnoux to the difficulty is the best one. It would certainly seem that a more promising field for experiment lies in the direction of modifying the *plan* form of the supporting surfaces (as in the Dunne machine) rather than in radically altering their cross section or turning them upside down. However, M. Arnoux has the courage of his convictions, and for this reason and also on account of its intrinsic worth, what he has to say merits attention. He does not mention the work of other experimenters in his field. Mr. Turnbull's experiments with various cross sections should be referred to. English Patent No. 8868/06 is of interest in this connection.—B. G. C.

Aerial Navigation. By Frederick Walker, C.E. (London: Crosby Lockwood, 1910. (Second Edition, pp. 164. 5s. net.)

The original edition of this book, which appeared in 1902, was—to speak gently—not good; the present edition, described as revised, is perhaps worse. In fact there is not a single feature about it which we can commend, except the unconscious humour of many of the illustrations. Mr. Walker had much better have refrained from this new appearance. To make a blunder is pardonable, but to repeat it is a crime.

Flying-Machines: Practice and Design. By Rankin Kennedy. (London: The Technical Publishing Co., Ltd., 1909; 5s. 6d.)

This book labours under a great disadvantage, in that the bulk of it would appear to have been written more than two years ago. In the meantime so much has happened in the world of aeronautics, that the value and interest of the work have depreciated considerably.

Some very clear explanations of the principles of flying machines are given in Chapter II., which should appeal to the average man interested in aeronautics, who, being no mathematician, is quite incapable of digesting a work such as Lanchester's "Aerodonetics." In considering the work done in an aeroplane, the most important factor is considered to be the velocity with which the air is thrown down by the planes; this point is not very generally recognised, although it would seem to be obvious enough.

Mr. Kennedy holds some curious views with regard to the gliding of aeroplanes after the engine has been stopped; a vol plané he considers impossible, unless the aeroplane is flying

low enough to land while it still has a certain amount of way on from the propeller thrust. There seems no particular reason why such a theory should ever have been propounded, but in any case the events of the last eighteen months should have been sufficient to dispose of it. Attention is called to the necessity of evolving some more useful form of flying machine than the simple aeroplane, and this cannot be too often insisted upon; whether the unconscious humour of Mr. Kennedy's designs will help us toward this end is another matter. On the whole, it is a little difficult to understand the exact reason for the publication of this little book.—L. G. D.

The Aviator's Companion. By Dick and Henry Farman, and others. (London: Mills & Boon, 1910. 102 pp. 5s. 6d. net.)

The publishers who have written a fore-note to this volume seem greatly worried by the anticipation of its failure. We cannot do much to reassure them. The only interesting matter in the book is in pp. 41–58, in which Henry Farman describes his early experiences, but the original of this appeared in French last year. There is a good chapter on that hackneyed subject, "Aviation Motors," and short accounts of Santos-Dumont, Ader and R. Esnault-Pelterie, but on the whole the little book strikes one as fulfilling no useful purpose.

Notable Flying Men. Compiled by the Staff of "The Motor." (London: Temple Press, 1910. 88 pp. 6d. net.)

An excellent publication, which we shall hope to see as an annual and enlarged. Short biographies are given of forty aviators, with portraits and with pictures of their machines. The biographies have the merit of being accurate, and the illustrations of being clear. A very good sixpennyworth.

Aeronautical Classics. No. IV. The Aerial Ship. By Francesco Lana. (London: Aeronautical Society of Great Britain, 1910. 1s. net.)

The fourth "Classic" fully sustains the reputation of this notable series. Francesco Lana (1670) was the first writer on the principles of ballooning, although his invention used a vacuum instead of hydrogen gas. The present volume contains the first English translation of the famous chapters of his "Prodromo," a full biography, a portrait, a facsimile of his original designs, and a reproduction of a very rare print showing the application of hydrogen to his idea. All members should buy it.

WANTED.—The Annual Reports of the Aëronautical Society for 1866, 1867, 1874, 1877, 1883–4. Apply, stating price, to the Secretary, Aëronautical Society, 53, Victoria Street, London, S.W.

WANTED.—The Aëronautical Journal, Nos. 2, 9, 26, 38, and 55.—Apply, stating price, to above address.

CORRESPONDENCE

AVIATION PROSPECTS IN NORTHERN NIGERIA

To the Editors of the AËRONAUTICAL JOURNAL

SIRS,—I am sorry that through press of work I was unable to reply sooner to the query *re* aerial navigation in Northern Nigeria. Nothing in this direction has been done in Northern Nigeria so far.

As regards the suitability of the climate the period of heavy rains is from June to September. This period is preceded and followed by about three weeks during which severe tornadoes are likely to arrive with very little warning. Thus, say, from May to October extended flights would be inadvisable. From December to March is the Harmattan, a steady north-easterly wind accompanied by a more or less dense haze. It is the most agreeable time of the year and I doubt if the haze would interfere with the otherwise apparently favourable conditions. The temperature varies from 60°—115° in the shade, and during the Harmattan the air is very dry.

The surface of the country is varied. It is on the whole gently sloping, with occasional abrupt hills rarely exceeding 400 feet in height above the surrounding country. At low water, March to June, along the River Niger, which is about one mile broad, the numerous sandbanks might afford suitable starting places for practice flights along the river, if loose dry sand is considered a suitable surface. The wind generally blows up or down. The main banks are densely wooded. There would be some difficulty in getting to the machine unless one arranged to start from the main land. A fall in the water would possess the additional element of excitement furnished by the presence of numerous crocodiles.

The country round Baro is covered with fairly dense bush except when under cultivation, and even the large areas under cultivation are dotted closely with Shea trees spared for their valuable fruit. The preparation of the ground for cultivation generally leaves it in hummocks like ant heaps about a foot high and three or four feet apart—not a suitable surface I should say for starting from. The whole country is covered with grass or crops up to 10 feet in height from July to December, when the grass is burnt down and the harvest commences. Of course there are some cleared and fairly level places which might be selected beforehand for possible descents, and further north the country is more open and the grass shorter.

I should say that when further developed, an aeroplane would be a most valuable method of progression to minimise the existing handicap to efficient supervision over vast areas provided at present with the most rudimentary means of communication, which limit one's progress to some 15 to 20 miles a day at the most, except on the newly constructed railway.

There remains the difficulty of kit (rarely less than 10 carrier loads = 5 cwt., for even a short journey) and native servants, interpreter, etc.—all indispensable when camping away from headquarters. But the necessity for camping in the bush would be lessened and special arrangements might be made when travelling between European centres.

It must be remembered that except on the railway there are absolutely no facilities for the repair of machines, or for replenishing the supply of petrol and stores, and that the hangars would be of the most primitive materials and workmanship except at the more important centres. Moreover, the corrosive and rotting action of the climate, not to mention the depredations of white ants and other pests, would necessitate special vigilance in the care of the machines.

H. O. MANCE,
Captain, R.E.

MEMORIAL TO P. S. PILCHER

SIRS,—It has been proposed to erect a pillar as a memorial to the late Percy Pilcher, a pioneer of aviation. It would, perhaps, be correct to say *the* pioneer of aviation, for it was Pilcher who thought out and put into practice the project of gliding through the air with rigid wings, and he had the intention of propelling with a motor the machine he had made.

Pilcher was the first Englishman to be killed in the cause of aviation, his fatal fall in Stanford Park, Market Harborough, taking place on September 30, 1899.

Many who knew him and appreciated his self-devotion and zeal in promoting aviation may like to contribute to the proposed memorial near the spot where he fell.

Subscriptions should be sent to the Pilcher Memorial Fund, Messrs. Barclay and Co. (Gosling Branch), 19, Fleet Street, E.C.

BRAYE
FRANK HEDGES BUTLER

[The late P. S. Pilcher, who carried on the work begun by Lilienthal, was a member of the Aëronautical Society, and at the time of his death a Member of the Council.—EDS.]

ANALYSIS OF FOREIGN PUBLICATIONS

ABBREVIATIONS

Aer., L'Aéronaute (Paris)
Aeron., Aeronautics (New York)
Aerop., L'Aérophile (Paris)
Aero-Mec., L'Aéro-Mécanique (Brussels)
C.-V., Le Cerf-Volant (Paris)
D.Z.L., Deutsche Zeitschrift für Luftschiffahrt. (Berlin)
Flug., Flug-und-Motor Technik (Vienna)
Rev. Aer., Revue Aérienne (Paris)
Rev. de l'Av., Revue de l'Aviation (Paris)
Tech. Aer., La Technique Aéronautique (Paris)

AEROSTATION

Doppelte Ueberquerung des Kanals. (Dr. Bamler.) "D.Z.L." July 18.
Luftschiffahrt am La Plata. (Thewalt.) "D.Z.L." September 7.
Luftschiffahrt in Niederländisch-Indien. (Rambaldo.) "D.Z.L." August 24.

AERODYNAMICS

Luftwiderstände. (Kraus.) "Flug." July 10.
Position du centre de poussée. (Rateau.) "Aérop." September 15.
Poussée sur les surfaces portantes des aéroplanes. (Soreau.) "Aér." July 23.
Qualités essentielles de l'aéroplane et de l'hélice. (Pagezy.) "Tech. Aér." July 15 *et seq.*
Résistance de l'Air. (Eiffel.) "Aér." July 16.
Résistance aérienne en Fonction de l'Incidence de 0° à 360°. (Amans.) "Aér." August 6.
Variation du coefficient SV^2. (Soreau.) "Aéro-Méc." August 10.

AERONAUTICS

Classification des différents modes de vol. (Sée.) "Tech. Aér." October 1.

AEROPLANES

Aéroplane "de Pischof." "Aéro-Méc." September 10.
Aéroplane "Gustave Mees." "Aér." October 8 and 15.
Flugapparat "Wright-Knoller." "Flug." September 10.

ALTITUDE

Physiologie des altitudes. (Crouzon.) "Aérop." September 15.

BIOGRAPHY

Charles Wachter. "Aérop." July 15.
C. K. Hamilton. "D.Z.L." August 24.
Edmond Poillot. "Aérop." October 1.
Emile Reymond. "Aérop." October 1.
Franz Clouth. "D.Z.L." September 21.
General Bonnier. "Aérop." October 15.
Jean Bielovucie. "Aérop." September 15.
Maurice Herbster. "Aérop." August 1.
Oscar Erbslöh. "Aérop." August 1.

BIRD FLIGHT

Comment volent les Oiseaux: Le Vol ramé. (Desmons.) "Aér." August 6.
Le Vol des Oiseaux. (Karville.) "Aér." October 15.
The Make-up of a Bird's Wing. (Rowe.) "Aeron." October.
Vols à voile circulaires. (Thouveny.) "Tech. Aér." September 15.

CHASSIS

Calculs des ressorts dans les châssis d'aéroplanes. (Petit.) "Rev. Aér." August 25.

CONTROLS: THEORY.

Dispositif de liaison entre le gouvernail de profondur et les ailes d'un aéroplane. "Tech. Aér." September 15.

DESIGN: AEROPLANES.

Les formes des Ailes et Carènes en Aviation. (Delens.) "Aérop." October 15.

DIRIGIBLES

Aérostat Métallique "Tziolkovski." "Aér." October 8.
Calcul des tensions de l'enveloppe d'un dirigeable. (Voyer.) "Tech. Aér." September 15.
Cloisonnement des dirigeables [suite]. (P. Renard.) "Rev. Aér." July 25.
Eclatement du dirigeable "Erbslöh," "Tech. Aér." September 15.
Katastrophe des "Erbslöh." (Spannung der Ballonhülle.) "D.Z.L." September 21.
Konstruktion der Ballonhülle im Prallballon. "D.Z.L." September 21.
Unglücksfahrt des Luftschiffes "Deutschland." "D.Z.L." July 18.
Vernichtung des Lenkballons "Erbslöh." (Krüger.) "Flug." September 24.

ELECTRICITY

Luftschiff im erdelektrischen Felde. (Volkmann.) "D.Z.L." August 10.

EXPLORATION

Plan einer geographishen Erforschung Neu-Guineas. (Dr. Wegener.) "D.Z.L." September 7.

GLIDING

Analyse élémentaire de la chute planée. (Jarkowski.) "Rev. Aér." August 10.

HELICOPTERES

Hélices de sustentation. (Bréguet). "Rev. de l'Av." August *et seq.*
Problème de l'Hélicoptère. (Varille.) "Aér." September 17.

HISTORICAL

Luftschiffahrt vor 250 Jahren. [Cyrano de Bergerac.] "D.Z.L." July 18.

HYDRO-AEROPLANES

Premier Aéroplane marin. "Aérop." September 1.
Sustentation dynamique dans la navigation en surface. (Saconney.) "Tech. Aér." September 1.

HYDROGEN

Procédés nouveaux pour la fabrication de l'hydrogène. (Espitallier.) "Tech. Aér." August 15. *et seq.*

KITES

Cerfs-Volants de Sauvetage. (Lecornu.) "Aér." July 30.
Forme des surfaces portantes. (Berthon.) "C.-V." July.
Mesure de l'altitude des surcharges élevées par cerf-volants. (Saconney.) "C.-V." September.

MILITARY

Bombardement par les dirigeables. (Bissari.) "Tech. Aér." October 1.
Hangars démontables pour Aéroplanes Militaires. "Aérop." October 15.
L'Aéronautique aux Grandes Manœuvres. (Lagrange.) "Aérop." October 1.

MOTIVE POWER

Aéroplanes et leurs moteurs. (Lalande and Noalhat.) "Aér." September 10 *et seq.*
Propulsion par réaction directé. (Lorin.) "Aérop." July 15.
Proving Horsepower—by Reaction. (Inman.) "Aeron." September.
Schmierung des Motors. (Popper.) "Flug." September 25.
Solution du moteur d'aviation. (Tartrais.) "Rev. de l'Av." September 1.
Wasser oder Luftkühlung. (Popper.) "Flug." August 25; September 10.

MOTORS

Aéroturbine J. A. Farcot-d'Albaret. "Aéro-Méc." September 10.
Moteur Laviator. (Couade.) "Tech. Aér." July 15.
Moteur d'aviation "Miller." "Aérop." July 15.
Nouveau moteur R.E.P. "Aérop." September 1.

NAVAL

Emploi, par la Marine, des appareils de locomotion aérienne. (Delaunay.) "Aérop." August 1.
Emploi des aéroplanes et dirigeables dans la guerre navale. (Piumatti.) "Tech. Aér." October 1.

NAVIGATION

Boussole et Cartes en Aéronavigation. "Aérop." July 15.
Die hohe Schule der Luftschiffahrt. "D.Z.L." September 7.
Procédés de navigation. (Legrand.) "Rev. Aér." September 25.

PHOTOGRAPHY

Balloon Photography. (Dr. Bamler.) "D.Z.L." September 7.

PROPELLERS

Luftschrauben. (Kraus.) "Flug." August 10; September 10.
Mesure de la poussée des hélices en plein vol. "Aérop." September 15.
Note sur les hélices aériennes. (Riabouchinsky.) "Tech. Aér." September 1.
Propeller Design and Construction. (S. Heath.) "Aeron." October.

STABILITY

Stabilité des aéroplanes biplans. (Joyeux.) "Rev. de l'Av." October.

WIRELESS TELEGRAPHY

Télégraphie sans fil à bord des dirigeables. (Ferrié.) "Aérop." September 15.

VACHER & SONS, Ltd.,
Printers,
Westminster House, S.W.

GENERAL INSTRUCTIONS FOR ALL COMMITTEES

1. The Committee shall fix a day for holding its meetings. Probably one day a month will be sufficient in most cases, but this will rest with the Committee.

2. The meetings can be held at the Society's rooms between the hours of 6 p.m. and 10 p.m.

3. Each Committee should appoint a member to act as Secretary to take general charge of papers, etc. The name of the Secretary should be reported to the Council of the Society.

4. Minutes of proceedings need not be kept, as it is most desirable to reduce all clerical work to a minimum.

5. All Committees will be informed by the Council as to the funds available for their work. The postage expenses of all Committees will be defrayed by the Treasurer out of the Society's postage account.

6. Technical Committees should draw up a programme of work and make an estimate of the cost of carrying out such work. Programme and estimate to be sent to the Council for their information.

7. It is suggested that Technical Committees should send in from time to time short reports of the work done by them, as it is most desirable that members should receive *early* information regarding experiments, etc., carried out.

For the Council,

(Signed) J. D. FULLERTON, Col. R.E.

SPECIAL INSTRUCTIONS

BIRD CONSTRUCTION COMMITTEE

Chairman:

E. P. Frost (President)

Members:

The Rt. Hon. The Earl of Lovelace; Col. Fullerton, R.E.; M. Holroyd Smith; Alex. Keith; S. Couper Coles; Wilson Carr.

1. The object of this Committee is to investigate the construction of birds from the aëronautical point of view.

2. It is suggested that the Committee should first of all consider and report upon—

(*a*) General dimensions of birds in weight, span, wing area, etc.

(*b*) The skeleton or framework and the joints or method of connecting the different parts.

(*c*) The muscular and nervous system of a bird.

Further details to be considered later.

3. The Council is specially desirous of publishing Report (*a*) at an early date.

4. The sum of £20 is available for the use of this Committee.

EXHIBITION COMMITTEE

Chairman:

E. S. BRUCE, M.A.

Members:

CHAS. BRIGHT; A. B. E. CHEESEMAN; T. O'B. HUBBARD; P. NARRAWAY; F. HANDLEY PAGE; G. P. DEVERALL SAUL

1. The duty of this Committee is to advise the Council as to the best Exhibitions at which the Society should make displays.

2. The Committee should also consider the suggestion that the Society should have a special exhibition of its own once a year, and whether charges should be made for admission to such an exhibition.

TECHNICAL WORDS COMMITTEE

Chairman:

MAJOR B. BADEN-POWELL (VICE-PRESIDENT)

Members:

C. A. ALDERSON; J. H. LEDEBOER; H. A. SYKES; C. C. TURNER

1. The object of this Committee is to ascertain the best words for general aëronautical use.

2. It is suggested that the Committee should first of all consider about 100 of the commoner words and draw up a list of them with their French, German, and Italian equivalents.

3. The Committee should communicate with persons other than members of the Society interested in this subject, and steps should be taken through the Secretary of the Society to ascertain the ideas of foreign Aëronautical Societies on the terms proposed.

COMMITTEE for the CONSIDERATION of INVENTORS' PROPOSALS

Chairman:

W. F. REID, C.E., F.I.C.

Members:

CHAS. BRIGHT, F.R.S.E., M.I.E.E.; CAPT. A. D. CARDEN, R.E.; CHAS. G. GREY; G. GURNEY GRIME; A. P. THURSTON, B.Sc.

1. This Committee is assembled for the purpose of examining and reporting upon proposals sent in by inventors. The Reports should be brief and clear, and comment in detail on the good and bad points of any scheme submitted.

2. The Committee should draw up a form of "Notice to Inventors," explaining the conditions upon which the Society undertakes to examine proposals. Care should be taken to safeguard the Society's interests, but inventors should be definitely informed that the Society will not make any charge for the services it renders.

LIBRARY AND MUSEUM COMMITTEE

Chairman:

THE PRESIDENT

Members:

CHAS. BRIGHT, F.R.S.E.; T. O'B. HUBBARD (LIBRARIAN)

1. This Committee is charged with the general care of the Library, Museum, etc.

2. It should forward a brief Report on the proposed expenditure for 1910 at an early date.

(*a*) Purchase of books, journals, etc.
(*b*) Binding requirements.
(*c*) Purchase of models.
(*d*) Purchase of lantern slides.
(*e*) Proposed model room.

LABORATORY COMMITTEE

Chairman:

W. F. REID, C.E.

Members:

R. M. BALSTON; CAPT. A. D. CARDEN, R.E.; H. DONNITHORNE; A. W. ISENTHAL, M.I.E.E.; F. HANDLEY PAGE; A. P. THURSTON, B.Sc.

1. The object of this Committee is to carry out scientific experiments and obtain data useful to the designers of aëronautical machines of all classes.

2. The Committee should forward brief reports on the following points:

(*a*) Accommodation for experimental work.
(*b*) Apparatus proposed to be constructed.
(*c*) Labour required for general charge.
(*d*) Estimate of cost of apparatus and labour for 1910.
(*e*) General programme of work for 1910.
(*f*) Brief general account of useful data available regarding the air pressure, centre of pressure, and line of action of air force on surfaces and bodies of different descriptions.

3. The above reports will no doubt take some little time to prepare, but the Council is specially desirous of getting Report (*f*) published as early as possible.

4. The sum of £200 is available for this work.

EXPERIMENTAL GROUND COMMITTEE

Chairman:

MAJOR B. BADEN-POWELL (VICE-PRESIDENT)

Members:

R. M. BALSTON; THE RT. HON. THE VISCOUNT HILL; C. A. MOREING, C.E.; J. NEALE

1. The object for which this Committee is assembled is to generally manage and control the Society's Experimental Ground.

2. As soon as the arrangements for the Experimental Ground are settled the Committee should forward brief reports as follows:

(*a*) Description of the work it is proposed to do at the Ground during 1910.
(*b*) Estimate of cost of proposed work.
(*c*) Statement showing any charges it is proposed to make for sheds, etc.
(*d*) A form of conditions for occupying sheds, etc., to be issued to all members using them and by which they must abide.
(*e*) Insurance arrangements, sheds, workmen, etc.

3. It should be noted that charges to members for sheds, etc., should be moderate as it is specially desirable that all members should be able to make use of the Ground without incurring great expense.

REVISION OF RULES COMMITTEE

Chairman:
E. S. BRUCE, M.A.

Members:
H. MASSAC BUIST; COLONEL F. G. STONE, R.A.

1. The general spirit of the present Rules should be adhered to.

2. The phraseology should be revised to meet modern requirements.

3. No larger number of Rules than absolutely necessary should be adopted. It is very desirable to have as few rules as possible.

THE FINANCE COMMITTEE

Chairman:
COL. H. E. TYLER, R.E. (HON. TREASURER)

Members:
DR. W. N. SHAW

1. The duty of this Committee is to assist the Hon. Treasurer in the general control of the Society's Finances.

2. The Committee should prepare a statement showing probable receipts and expenditure for 1910 as soon as the Council has decided upon the grants to be made to the various Technical Committees. Such statement, when approved by the Council, will form the basis of the financial proposals for the year.

WINGS COMMITTEE

Chairman:
F. HANDLEY PAGE

Members:
T. B. BAKER; S. F. BARCLAY; J. LEDOUTHET; THE HON. HENRY S. LITTLETON; P. NARRAWAY; A. CHATTERTON SIM

1. The object of this Committee is to consider the use of the wing as a mechanical device in flying.

2. The Committee has already issued one report on this subject, and the Council hopes that it will carry on some further experiments, especially upon the thrust, lift, etc., of wings when the whole machine is in forward movement.

3. The sum of £50 is available for such experiments.

For the Council,
(Signed) J. D. FULLERTON, COL. R.E.

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NOTE.—Members are requested to forward to the Assistant Secretary on or before August 30 next any suggestions they desire to make in reference to the following Amended Rules, which have been drawn up by the Revision of Rules Committee under the direction and supervision of the Council.

THE AËRONAUTICAL SOCIETY OF GREAT BRITAIN

RULES

(As Revised by Council, July 11, 1910)

I.—OBJECTS

The Society was established on January 12, 1866, for the purpose of giving a stronger impulse to the scientific study of Aerial Navigation. Its aims embrace theoretical and practical research into all phases of the problem, by any suitable means, such as Laboratories, Experimental Grounds, and so forth; the promotion of intercourse between those interested in the subject at home as well as in different parts of the British Empire and abroad; the aiding with advice and instruction those studying the subject; the organising of meetings, lectures, discussions, exhibitions; the issuing of publications, as well as the maintenance of a Library of Aeronautical works, etc., etc.

II.—CONSTITUTION

1. The Society shall consist of Members and Honorary Members, already elected, and to be elected in manner hereinafter mentioned.

2. The Society shall be under the management and direction of a Council, consisting of a President, six Vice-Presidents, Hon. Treasurer, Hon. Secretary, and twelve other Members of the Society.

III.—ELECTION OF THE OFFICERS AND COUNCIL

3. The Council shall be elected out of the Members.

4. The Members of the Council, including President, Vice-Presidents, Hon. Treasurer and Hon. Secretary, shall be proposed for election by the Council annually and elected by the Members of the Society by ballot at the Annual General Meeting.

5. Two Vice-Presidents and four of the twelve ordinary Members of the Council shall retire annually and shall not be eligible for re-election for one year following their term of office.

6. The President, Hon. Treasurer, and Hon. Secretary shall be eligible for re-election.

7. A copy of the ballot paper for the election of Council and Officers shall be sent to every Member of the Society a month previous to the date of the Annual General Meeting, and shall be returned to the Hon. Secretary at or before the Meeting; Members may erase any name or names from the ballot list and may substitute the name or names of any other person or persons, but the number of names on the list after such alterations must correspond with the number shown on the original list; Members obtaining the greatest number of votes shall be elected.

8. If in the interval elapsing between two Annual General Meetings there should occur a vacancy or vacancies amongst the offices of the Society or on the Council, the Council shall have power temporarily to fill up the vacancy or vacancies.

IV.—ELECTION, ADMISSION, EXPULSION, AND PRIVILEGES OF MEMBERS

9. Every person desirous of admission into the Society as a Member must fill up and subscribe his or her name to the form which accompanies the prospectus (unless specially excused therefrom) and be elected at a Meeting of the Council; candidates must be proposed by a Member and seconded by a Member of the Society, and every facility shall be afforded to applicants.

10. Ladies are eligible as Members.

11. No person shall be considered as elected a Member unless he have in his favour at least two-thirds of the Council voting.

12. When a person shall have been elected a Member, the Hon. Secretary shall inform him thereof by letter as soon as possible, and shall at the same time, or as soon after as possible, forward to him a copy of the rules of the Society.

13. Every person so elected shall pay his or her entrance fee and first annual contribution within one calendar month after the day of election, otherwise the election shall be void; but the Council shall have power, in particular cases, of extending the period of such payment.

14. Should there appear cause, in the opinion of the Council, for the expulsion from the Society of any Member, the Council shall direct the Hon. Secretary to inform the Member that such a course is proposed to be adopted at the next Meeting of the Council and of the reason for so doing, and in the absence of satisfactory explanation on the part of the Member, the Council may proceed to vote for the Member's expulsion, and he shall be expelled, provided that not less than two-thirds of the Council then present shall be in favour of that course.

15. Any Member who has not paid his annual subscription at the end of any given year, notice having been sent to him that it was overdue, shall be liable to have his name removed from the list of Members.

16. Every Member (who has paid his subscription for the current year) is entitled to:—

(*a*) Be present and vote at all General Meetings of the Society.

(*b*) Receive one copy of each report or publication issued by the Society after he shall become a Member.

(*c*) Admission with two friends to every ordinary Meeting of the Society, except on special occasions when the number of visitors may be limited.

(*d*) Consult any books or publications in the Library, but must bear any expense (such as postage) connected therewith; Members shall be responsible for the safe custody and the condition of such books which may be in their charge.

V.—CONTRIBUTIONS OF MEMBERS

17. Each Member shall, upon his election, pay an entrance fee of one guinea and his first annual subscription of one guinea, and shall for each subsequent year pay a subscription of one guinea, dating from January 1; should he join during the last three months of the year he will be exempt from subscription for the year following.

18. Any Member may, at his entrance, compound for his annual subscriptions by the payment of fifteen guineas, or he may, at any time afterwards (all sums then due being first paid), compound for his subsequent annual contributions by the like payment of fifteen guineas.

19. Every Member desirous of resigning shall be liable to the payment of his annual contributions until he shall have signified such desire in writing to the Hon. Secretary of the Society one month, at least, before he enter into another year and shall have discharged his arrears.

20. If any Member change his residence he shall forthwith give notice thereof to the Hon. Secretary.

VI.—HONORARY MEMBERS

21. Every person eminent in any of those branches of science advocated by the Society, and not having a permanent residence in the United Kingdom, or who, for other reasons, is not desirous of becoming an ordinary Member, shall be eligible as an Honorary Member.

22. The mode of proposing and voting, or balloting for an Honorary Member shall be the same as that prescribed in the case of a proposed ordinary Member, but no person shall be elected an Honorary Member unless each Member of the Council has had at least three weeks' previous notice from the Hon. Secretary that it is intended to proceed to his election at its next Meeting.

23. Whenever a person shall have been elected an Honorary Member the Hon. Secretary shall inform him thereof and forward to him his diploma, according to such form as may be provided by the Council.

24. Honorary Members shall not have the right of holding any office in the Society, but may vote at any General Meeting of Members which may be called.

VII.—THE COUNCIL

25. The Council shall have the management and direction of the affairs of the Society.

26. The Council shall meet whenever considered expedient, but the President or any three Members of the Council may, by letter to the Hon. Secretary, require an extra Meeting of Council, or a General Meeting of Subscribers to be called.

27. Due notice of each Meeting of the Council shall be sent by the Hon. Secretary to every Member thereof.

28. Three Members of the Council shall constitute a quorum.

29. All questions shall be decided in the Council by vote, unless a ballot be demanded.

30. The Council shall draw up a report on the state of the affairs of the Society, to be presented annually to the Members. In this report shall be given an abstract of its proceedings during the year.

31. The Council shall have power to employ and remunerate such officers as may be required for conducting the business of the Society.

32. Minutes of the proceedings of the Council shall be taken by the Hon. Secretary, or some other person on his behalf, which shall be afterwards fairly entered into the minute book, and, having been read over at the next Meeting of the Council, shall be signed by the President or other Member then in the chair.

VIII.—MEETINGS OF COUNCIL

33. The business of the Council Meetings shall be to examine the qualifications of Candidates for election, to propose and vote for the election of new Members and Honorary Members; to propose for election annually the Council, President, and other Officers of the Society to be elected by ballot at the Annual General Meeting; temporarily to fill up vacancies amongst the Officers of the Society or on the Council; to examine the reports of sub-committees and decide as to whether the recommendations of the same shall be adopted; to determine the nature of the experiments to be conducted, and the amount of support to be rendered to inventors upon their application for that purpose, and to afford them the opportunity of personal explanations as to the merits of their inventions generally and to discuss and vote on all subjects pertaining to the conduct of the affairs of the Society.

IX.—ORDINARY MEETINGS

34. There shall be, at least, three ordinary Meetings of the Society in the year. The business of the ordinary Meetings shall be the announcement of any

matter of importance or interest to the Society. To read such communications relating to Aeronautics and the subjects connected therewith as may have been presented to the Society and approved of by the Council; but at the ordinary Meetings nothing relating to the Rules or management of the Society shall be proposed or discussed.

X.—SPECIAL GENERAL MEETINGS

35. A General Meeting shall be held between January 1 and March 31 each year, the precise date to be determined by the Council, to receive and approve the report of the Council on the state of the Society and the Balance-Sheet; to discuss and determine such questions as may be proposed by the Council or Members relative to the affairs of the Society, and to elect the Officers and Council for the ensuing year; notice of not less than fourteen days shall be given in writing to the Hon. Secretary by Members proposing any subject for discussion at a General Meeting.

36. The President or Chairman shall appoint two or more scrutineers from amongst the Members present at the Annual General Meeting to superintend the ballot for the election of Officers and Council, and to report the same to the Meeting.

37. The Council may, at any time, call a Special General Meeting of the Society.

38. Any twenty Members of the Society can request the Council to call a Special General Meeting by a letter addressed to the Hon. Secretary giving full explanation of their purpose in so doing, and such a General Meeting shall be called within one month after the reception by the Hon. Secretary of the said letter.

XI.—ALTERING THE RULES OF THE SOCIETY

39. When the Council consider it advisable to propose the introduction of a new rule or the alteration or repeal of an existing rule they shall recommend the same to the Society at the Annual General Meeting or shall call a Special General Meeting for the purpose.

40. No resolution altering or repealing any rule or introducing any new rule can be proposed at a General Meeting by the Members unless twenty Members have recommended such a measure to the Council in a letter addressed to the Hon. Secretary and received by the Hon. Secretary at least a fortnight before the date of the Meeting.

XII.—SCIENTIFIC AND OTHER COMMITTEES

41. Committees for forwarding scientific objects connected with Aeronautics, or for dealing with matters relating to the work of the Society, may, from time to time, be appointed by the Council, to whom their reports shall be submitted. In the formation of these Committees the Council may request the assistance and advice of persons not Members of the Society.

XIII.—THE PRESIDENT AND VICE-PRESIDENTS

42. The duty of the President shall be to take the chair at every Meeting of the Society and Council, to regulate and keep order in all the proceedings, and to carry into effect the Institutes of the Society.

43. In the absence of the President one of the Vice-Presidents, or in their absence any Member of the Council shall take the chair and conduct the business of the Meeting.

44. The President or other Member in the chair shall not vote on any question brought before the Meeting, except where a casting vote is necessary, in which case he shall be required to give such casting vote.

XIV.—THE HON. TREASURER

45. The Hon. Treasurer shall receive all sums of money due to the Society, and, so far as its funds extend, pay all its liabilities.

46. He shall keep a regular account of receipts and of payments ordered by the Council, who shall have the direction and control of the money in his hands.

47. No sum of money amounting to more than £40 shall be paid, except by order of the Council, signed by the President or other Member in the chair and countersigned by the Hon. Secretary.

48. The Account of the Hon. Treasurer shall be audited annually by one or more Auditors, appointed by the Council for that purpose, who shall report to the Council the particulars of the receipts and expenditure of the past year, the balance in hand, and the general state of the funds and property of the Society, and shall also present a list of the names of those Members who may be in arrear for sums due up to the date of their report.

XV.—THE HON. SECRETARY

49. The duty of the Hon. Secretary shall be to attend all the Meetings of the Society and of the Council. In his absence such duties may be performed by any Member of the Council. To take minutes of all their proceedings and cause them to be entered as early as possible in the proper books provided for that purpose; to read the minutes of the preceding Meeting and to announce the donations made to the Society since the last Meeting; to give notice of any candidate proposed for admission or to be balloted for; and to read the letters and papers presented to the Society; but should any person be desirous of reading his own paper or explaining his own plans he shall be at liberty to do so, with permission of the Council.

50. The Hon. Secretary shall have the superintendence of all persons employed by the Society and shall have the management of the correspondence of the Society, subject, however, to the direction and control of the Council.

XVI.—THE LIBRARY

51. The President, Hon. Secretary, and Librarian shall have the superintendence of the Library and other like property, and shall be a permanent committee for that purpose.

52. A Catalogue of the books presented, or purchased by the Society, and of all instruments, models, manuscripts, tables and other like property, with the names of the respective donors, shall be kept under the superintendence of the above Committee.

XVII.—THE PROPERTY OF THE SOCIETY

53. The President, one Vice-President, and the Hon. Treasurer shall act as the Trustees of the funds of the Society to be invested. The Council shall, from time to time, decide on the mode of investing the property of the Society, which investment shall be made in the names of the Trustees for the time being.

54. Every paper which may be presented to the Society shall, in consequence of such presentation, be considered as the property of the Society unless there shall have been any previous engagement with its author to the contrary; and the Council may publish the same in any way, and at any time, they may think proper. But should the Council refuse or neglect, within a year, to publish such paper, the author shall have a right to copy the same and publish it under his own directions. No other person, however, shall publish any paper belonging to the Society without the previous consent of the Council.

55. Books, papers, or drawings may be lent with leave of the Librarian or person acting as such for the time being for a period not exceeding three weeks. Every Member shall be at liberty, during such hours as the Library of the Society is appointed to be open, to inspect the printed books and such papers as the Council may permit, and to take abstracts therefrom.

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